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GEOGRAPHICAL REVIEW

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OUR CONTRIBUTORS

DR. SHAW, formerly of the U. S. Geological Survey, is a consulting geologist. His special fields of interest include erosion and sedimentation, studies of which he has carried on in various parts of the world. He has also conducted extensive investigations for oil, in the course of such work in South America (1920) exploring and mapping a large area. MR. DARNELL, associated with Dr. Shaw on the Maranhão expedition, is an engineering student.

MISS WILSON is associate professor of geography at the State Normal College, Ypsilanti, Mich. Her paper is based on field work in the summer of 1924.

MR. CLAPP is a consulting geologist specializing in petroleum. In 1914, in association with others, he was engaged in geological investigation in northern China. To the *Geographical Review* he has contributed the articles, "Along and Across the Great Wall of China" (April-June, 1920) and "The Hwang Ho, Yellow River" (January, 1922) and, with Myron T. Fuller, "Loess and Rock Dwellings of Shensi, China" (April, 1924).

MR. SYKES has for many years been associated with the Desert Laboratory of the Carnegie Institution, Tucson, Arizona. He has intimate knowledge of the arid southwestern United States in both physical and historical phases, and he has made comparative desert studies in the Libyan Desert (*Bull. Amer. Geogr. Soc.*, Vol. 44, 1912). His studies in historical cartography include the papers "The Mythical Straits of Anian" and "The Isles of California" in the *Bulletin of the American Geographical Society* (Vol. 47, 1915).

PROFESSOR HOBBS is professor of geology in the University of Michigan. In the broad sphere of his interests special mention may be made of his work in seismology and glaciology. His writings include "Earthquakes" (1907); "Characteristics of Existing Glaciers" (1911); "Earth Evolution and Its Facial Expression" (1921); "Cruises Along By-ways of the Pacific" (1925). To the *Geographical Review* he contributed a paper on his journey to northeast Africa for the study of desert conditions (Vol. 3, 1917).

MR. WORTHINGTON C. FORD, historian and economist, is editor in the Massachusetts Historical Society and has done much work in bibliography and historical research. In preparing the new catalogue of the John Carter Brown Library he gave attention to maps and map making, and the essay on the Smith map is one of the by-products. He is the author of "Captain John Smith's Map of Virginia, 1612" in the July, 1924, *Review*.

DR. CHU, who studied meteorology and climatology at Harvard, is a professor in the National Southeastern University, Nanking, China. He is the author of "Some Chinese Contributions to Meteorology" in the *Geographical Review* (Vol. 5, 1918).

MR. COULTER is an instructor in geography at the University of Chicago.

PROFESSOR JEFFERSON is professor of geography at the State Normal College, Ypsilanti, Mich. His varied geographical studies include especially investigations into population distribution and climatology in its human aspects. His writings include "Principles of Geography" (1926), "Man in Europe" (1924), "Recent Colonization in Chile," and "The Rainfall of Chile," *Amer. Geogr. Soc. Research Ser. Nos. 6 and 7* (1921).

MR. GREGG during the war was staff officer of the Shipping Section of the General Staff and later acted as adviser on shipping matters for the American International Corporation. He is now Chief of the Transportation Division of the Bureau of Foreign and Domestic Commerce. To the *Geographical Review* he contributed the paper "The Influence of Geographic Factors on Ocean Shipping" (Vol. 12, 1922).

MR. HARDY has served as a hydrographic and geodetic engineer of the U. S. Coast and Geodetic Survey in the Philippine Islands, Alaska, and on the home coasts. From 1911 to 1920 he was in charge of field parties engaged in executing topographic and hydrographic surveys and since 1921 has been in charge of the Section of Field Work of the Washington office of the Survey.

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Map of Hispanic America, 1:1,000,000 [15.78 miles to 1 inch], Provisional Edition, Sheet South E–19, LA PAZ, 1922. Sheet South C–19, ACRE, 1924. Sheet North G–12, BAJA CALIFORNIA-SUR, 1924. $2.00 each sheet.

Map of Hispanic America, 1:6,000,000 [about 100 miles to 1 inch], compiled from nearly 250 sources and showing railways, drainage, international and administrative boundaries, and towns in graded sequence down to those with a population of 4000. Produced in black in three sheets—measurements of 2 (to border) are 34 x 28 inches, and of the third 32¼ x 30 inches. 1922. $5.00.

Map of Alaska, 1:1,250,000 [about 20 miles to 1 inch], compiled from over 200 maps and charts. Printed on two sheets in five colors. Shows drainage, relief (1000 feet contours), settlements and towns (1920 census population given where available), communications, national parks, forests, etc. Size of two sheets when joined 49½ x 62½ inches to outer border. 1923. Unmounted, $2.00 (postage 25 cents); library edition mounted on cloth, $5.00 (postage 50 cents).

Separate Maps published in the *Geographical Review* and the *Bulletin of the American Geographical Society*, the majority in color. 25 cents each. A list will be sent upon request.

THE
GEOGRAPHICAL REVIEW

VOL. XVI APRIL, 1926 NO. 2

A FRONTIER REGION IN BRAZIL
SOUTHWESTERN MARANHÃO

E. W. Shaw and J. L. Darnell, Jr.

[With separate map, Pl. I, facing p. 194]

A PERIPHERAL civilization succeeding a peripheral colonization: thus Delgado de Carvalho, the Brazilian geographer, describes his country.[1] The coast settlements of Brazil have deep roots in the past, but to this day about half the great interior is unknown save for the rivers, which have been followed by rubber gatherers, by gold and diamond seekers, and by a number of explorers. The interfluvial areas, such as that between the Xingú and Tapajóz which is the objective of Colonel Fawcett's present expedition,[2] remain enveloped in mystery. The eastern border of the unknown interior is the hinterland of civilized peripheral Brazil. The inner border of this periphery is defined by a series of frontier settlements. Like all such settlements they have a geographical interest far exceeding their intrinsic importance.

The southern part of the state of Maranhão between the Tocantíns and Parnahyba Rivers is an illustration in point. Here we find, for instance, Carolina, a town of some 1200 or more people on the Tocantíns. Carolina connects with São Luiz on the seaboard by a complicated system of mule trail, river, and railway. Communication is highly irregular and may take weeks or months. Carolina is in the midst of fertile agricultural land, but its important traffic is in cattle and hides. Annually some 10,000 head of cattle pass through on their way to the coast. Not only much of southwestern Maranhão is com-

[1] C. Delgado de Carvalho: The Geography of Brazil in Relation to Its Political and Economic Development, *Scottish Geogr. Mag.*, Vol. 34, 1918, pp. 41–55.

[2] *Geogr. Rev.*, Vol. 25, 1925, pp. 210 and 520.

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mercially tributary to Carolina, but a large territory in Goyaz across the Tocantíns. Carolina thus shares somewhat in the mining interests of that state. Today, for instance, the town takes much interest in the new diamond districts of northern Goyaz.

The map, Plate I, facing page 194, shows the situation of southern Maranhão, and gives the first accurate mapping of a portion of the region. It is a country of tabular relief—of flat-topped hills, table-lands, and terraces. Published maps showing mountain ranges are misleading: serrate divides are absent; broad, flowing curves characterize the upland flats, which are sharply defined, cut by narrow river valleys, with narrow parallel drainage basins and relatively few tributaries.

Another misapprehension is in regard to the vegetative cover of the region. Along the coast the interior is spoken of as open; whereas in fact practically the entire state is forested, though the interior woodland is much less dense and more scrubby than that of the coast. The mineral wealth also is practically an unknown quantity, though gold, iron, manganese, copper and other minerals have been reported.

It was to investigate the mineral and timber resources of Maranhão that an expedition was undertaken in 1924 by the authors of this paper and Mr. W. H. Wright. Work was begun in the known gold-producing area in the northwestern corner of the state, and here Mr. Wright continued, while in the latter half of the year the other two members traveled across the state and into the southwest.

São Luiz to Coroatá

The southwestern trip began on August 15 from the capital São Luiz, the first 100 miles being made by rail southward along the Itapecurú River to Coroatá. The island of São Luiz, on which the capital is situated, is hilly, the relief along the railroad ranging from 20 to 50 feet. Between the hills are swamps and rather narrow V-shaped valleys. A very small fraction of the land is in cultivation; the greater part is covered with dense brush and small palms. Trails and houses are not numerous; but several small towns are passed before leaving the island, which on the south side is separated from the mainland by a deep muddy tidal channel about 250 feet wide.

On the mainland the railroad runs on the flood plain for many miles and generally a mile or more from the river. Occasionally one side or other of the valley, apparently less than 50 feet high, can be seen. Occasional groves of palms rise high above the tall thicket of other woods. Here and there are fields of pineapples and groves of bananas and oranges. The towns seem small and the houses scarce, considering that this is probably the most used transportation and travel route in the state, the railroad, river, and a through trail running

FIG. 1

FIG. 2

FIG. 3

FIGS. 1, 2, 3—Types of vegetation in Maranhão. Figure 1 shows tall palms lining a watercourse; Figure 2, a swamp due to the backing up of stream water; Figure 3, open country near Riachao—these open spaces are rare.

close together. Rosario, for example, looms large on the map; and the municipality—corresponding to our county—is listed in the 1920 census as having 17,153 people, yet the town seems to have only about 100 houses.

Coroatá is built on a large sandy flat, either a low terrace or a high portion of the flood plain. The river is 35 to 40 feet below in a deep, narrow channel not over 100 feet wide and borders the town on the east and north. The town seems to have less than 150 houses, though the population of the municipality is said to be 16,500. We saw no indications of any geological formation other than Tertiary and Quaternary sandstones.[3] The streets are deep sand, which drifts a little and in a region of stronger winds would develop dunes. The people and houses have an appearance of a little greater prosperity than those along the coast; the country is higher and drier, and the forest somewhat less thickety.

Coroatá to Pedreiras

From Coroatá we proceeded by mule to Pedreiras, 53 miles distant, on a trail cleared to cart-road size in places though apparently little used for vehicular traffic. The largest stream crossed was about 25 miles from Coroatá and was about 30 feet wide and 18 inches deep. Many channels were dry; watering places in fact are not very numerous along the trail in August.

The peculiar hardened subsoil known as canga[4] is widely developed here as well as in other parts of the state; it caps hills 30 to 50 feet high and seems to become more resistant with weathering.

The country continues undulating and sandy. The total relief along the trail is probably less than 200 feet, and over considerable stretches it does not seem to be more than 75 feet. For the most part the forest is so dense and the relief so gentle that one cannot see 50 feet. The forest is a tall thicket with a varying percentage of low palms and here and there, especially along streams, groups and lanes of tall palms rising two or three times as high as the thicket, whose top is 40 to 50 feet above the ground. Less than 100 trees measuring over 14 inches in diameter were seen, and most are less than six inches. Oranges and bananas are fairly plentiful along this trail, and houses are numerous where chickens, eggs, and other produce may be had at

[3] Except for the granite area of northwestern Maranhão the Tertiary extends from the coast inland about 100 miles. Farther inland the best published geologic map (J. C. Branner: Mappa Geologico do Brazil, *Bull. Geol. Soc. of America*, Vol. 30, 1919, opp. p. 189) shows upper Permian overlain in places by Triassic and Cretaceous with the granite showing through in certain localities. This map is only a first approximation, for there has been almost no geologic study of the state, and it is subject to much revision. Most if not all the scattered granite areas shown are erroneous, particularly those at Coroatá, Grajahú, Carolina, and south of Barra do Corda. A collection of fossils from near Carolina is said by the late J. M. Clarke to be probably Permian.

[4] On canga see E. C. Harder and R. T. Chamberlin: The Geology of Central Minas Geraes, Brazil, *Journ. of Geol.*, Vol. 23, 1915, pp. 341–378 and 385–424; reference on pp. 374–376.

FIG. 4

FIG. 5

FIG. 6

FIGS. 4, 5, 6—Typical flat-topped hills of southern Maranhão. Figure 4 is the Morro Vermelho. A thick layer of canga is seen capping the hill on the extreme left of Figure 6.

prices about half those for the United States but roughly twice as high as in the country 100 to 400 miles farther inland.

Pedreiras is built on the east bank of the Mearim River and is a shoestring town more than a mile long. The valley side, about 75 to 100 feet high, is only 100 to 200 yards from the river; and the town is built partly on high flood plain and partly on the gently sloping base of the valley side.

FIG. 7—The town of Barra do Corda looking west from the Cross (see Fig. 8).

THE CORDA RIVER

At Pedreiras we arranged with a man who was leaving shortly with a small steamer and a barge for Barra do Corda to take us and our baggage to that point. The steamer was about 30 feet long and six-foot beam, with a small boiler; and the barge which it towed was perhaps 50 by 12 feet. This kind of an outfit for carrying passengers and freight by river has lately become fairly common, though the average wait for a boat is likely to be at least a week or two.

The river, like almost all others of any size that we saw on the trip, is narrow, deep, and crooked with sharp V-shaped bends. Boats rarely run aground but are continually striking the branches or banks along their sides. One recalls Wells's despair over mapping the course of the Chapada: "So far there had not appeared a straight piece of the river longer than 100 yards."[5] Two other striking characteristics of the river are its bank-full appearance even at this low-water time of the year and the drowned and often barred or dammed mouths of tributaries. Clearly the river is at times 15 to 20 feet higher than at

[5] J. W. Wells: Exploring and Travelling Three Thousand Miles Through Brazil from Rio de Janeiro to Maranhão (2 vols., London, 1886) Vol. 1. p. 272.

present, yet brushy vegetation is so vigorous that it follows the water edge down every year and seems to wade out a few feet into the stream.

The people along the river cut the firewood and pile it on the banks. The sticks, three feet long and two to three inches thick, sell for

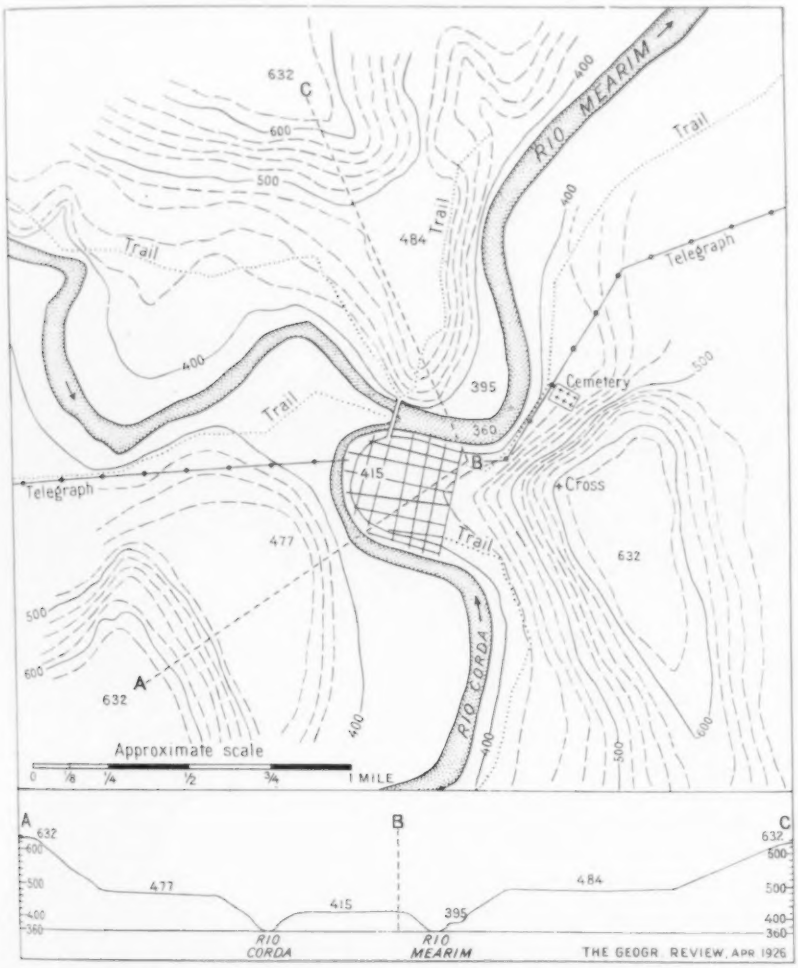

FIG. 8—Map and cross section of the environs of Barra do Corda.

about twenty cents a hundred. Often there is no woodpile in sight when fuel is needed, and the crew must go ashore to cut a supply. The annoyance of such delays is greater than that of the mosquitoes, gnats, and other insects and greater than that of the discomforts due to the cramped condition of the boat and occasional exposure to showers. The rivers have a bad reputation for malaria and other ills, comparing unfavorably in this respect with the trails.

At numerous places where there was engine trouble or wood to be loaded we went ashore and climbed the valley side.[6] Occasionally we found narrow terrace deposit remnants, which seemed to fall into three groups distinguishable by their altitude above stream but not by their form or composition. However, the evidence did not suffice to show conclusively that all were not accidental remnants of old alluvial deposits left at all altitudes above stream.

Barra do Corda

Barra do Corda, like Coroatá and part of Pedreiras, is built on a low terrace 35 to 40 feet above low water. The town is bordered on the south and west by the Corda River and on the north by the Mearim, into which the Corda empties at the northwest corner of the town. In times of marked rise of water the Corda is said to have generally an upstream current from its mouth, furnishing further evidence that the Mearim usually rises faster than its tributaries, which in this way develop bars across their mouths. The bar at this point gives rise to the name of the town. For the year as a whole, however, the Corda seems to have at least half as great discharge as the Mearim at the confluence, and both streams have almost no flood plains. High water last year reached 17 feet above low water. The rivers are about 100 feet wide and a few miles upstream begin to have occasional shoals and rapids. There are two 10-to-15-foot waterfalls on the Corda about 15 miles upstream, and there is a rapid on the Mearim about two miles above town. The river valleys have fragmentary terrace deposits at three levels—about 130, 180, and 220 feet above low water. The uplands are strikingly flat and at accordant altitudes a little under 300 feet above low water.

Table I—Mean Monthly Temperature (°F.) and Rainfall (Inches)*

Barra do Corda	D.	J.	F.	M.	A.	M.	J.	J.	A.	S.	O.	N.	Year
Temperature	79	78	78	78	78	78	76	76	78	81	81	81	78.5
Rainfall	4.8	4.8	7.0	6.3	3.8	2.4	.7	.3	.5	1.1	1.7	3.3	39.7
São Luiz													
Rainfall	6.6	7.5	9.6	18.8	16.4	12.5	5.7	4.5	1.1	.5	.4	.7	84.6

* Henrique Morize: Contribuição ao estudo do clima do Brasil, Rio de Janeiro, 1922.

At the time of our visit, early September, the air seemed dry and the soil rather parched. Maranhão lies between the heavy rainfall region of the Amazon, where more than 80 inches fall annually, and

[6] The Tertiary-Permian stratigraphic boundary appears to cross the river near Angelim.

the dry belt running south through the eastern tip of Brazil, where the average rainfall is less than 20 inches and where disastrous droughts occur in some years. Probably the average rainfall for the entire state is about 60 inches. Yet the dry season in the interior is at times so severe that stock suffer for lack of pasture. The wet season in Maranhão generally lasts from December to June; and the contrast of seasons is most pronounced along the coast, where in the wet season it rains a little almost every day, particularly around noon and midnight. In the interior the seasons seem to come a little earlier than along the coast. The temperature is uniform and ranges generally from 75 to 95 degrees the year around. In the latter part of the wet season the nights are somewhat cooler, but in November at Barra do Corda it was almost impossible to get water down to a temperature suitable for developing pictures. As usual in the interior there were gentle breezes; strong winds are said to be unknown. Once or twice a week through the dry season showers occur, generally with a gentle breeze from the east.

Barra do Corda to Grajahú

On September 10 we started for Grajahú over a trail that followed the east valley side of the Mearim for about 25 miles, then the west side for about 35 miles, and thence over the flat upland southwest to Grajahú. We were accompanied by the Rev. Perin Smith, a missionary resident at Barra who rendered us much assistance.

The upper Mearim approaches very close to the Grajahú. The upland between, chiefly sandstone, carried the most open and scrubby timber seen so far. It is *chapada*, or campos, country. Much good pasture grass grows between trees, and many cattle are raised. There are curious swamplike depressions on the upland, and at one place we saw a freshly drowned forest apparently due to a dam produced by rain washings from a trail crossing the depression.

Grajahú is a rambling town built on both sides of the river, which has a little toll footbridge that is removed during high water. The valley is narrow, nearly 400 feet deep, and has practically no flood plain. The town is built on the slopes, which are a little more gentle here than up or down stream. Like Barra it stands at the head of navigation, rapids and shoals being found upstream, but it can be reached only during high water and with shallow-draft boats.

Some oil shale outcrops at Barra, but it is too thin and under too much overburden to be of more than local interest. At Grajahú we found an outcrop of igneous rock, a lava[7] weathered soft and porous almost throughout, even in the river channel. The deeply decomposed condition of the rock at the surface and the extensive occurrence of

[7] Indications suggest that it is in part extrusive and was somewhat eroded before the end of Permian (?) time.

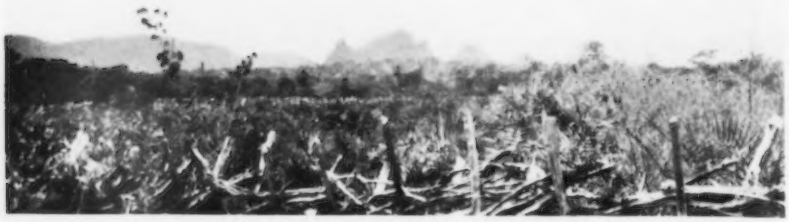

FIG. 9.—Fantastically weathered hills of horizontally bedded sandstone north of Carolina.

green stains and malachite of varying purity seem to warrant drilling for copper.

GRAJAHÚ TO SERRA DO NEGRO AND RIACHAO

The trail to Serra do Negro runs up the east side of the river along the valley slope since, as usual, there are only fragmentary bits of flood plain and low terrace along the river. At 15 miles from Grajahú the trail is on the upland flat about 1100 feet above sea. At São Julien the upland is a little less flat and rises toward Serra do Negro, which we approached in a southerly-westerly direction, eventually following a trail to its flat top—an area of about 12 by 20 miles cut by a clear rapid stream from four to six feet wide and several inches deep. The elevation of the Serra we determined as 2200 feet.

A complete explanation of the striking features of the topography of the country—the sharp angles at the tops and bases of the table-lands, the slight development of dendritic dissection, and the occasional long troughs that seem still in process of development—has not been fully evolved; but two controlling factors are evidently at work, the sandy soil and sapping at the wet-season level of ground water and the tendency of the subsoil, also not yet fully explained, to become crusty and resistant, developing canga. Apparently profiles are not becoming more broad and flowing, but flats retain their flatness while gradually migrating, and escarpments seem to retain their steepness, though how the sand is transported away from their bases is not yet clear.

The canga may be due in part to tropical climate, though the highest temperatures are no higher than are common in the temperate zone, and canga is not everywhere developed in tropical regions. The exact conditions requisite to the development of this material are not yet known, but it may be suggested in passing that in many different climates there seem to be conditions under which certain materials, particularly those having interstitial spaces in which iron oxide or silica may be precipitated, become more resistant with weathering. In the country traversed the canga shows considerable range in

FIG. 10—Residual southwest of Serra do Negro.

thickness and character, and its irregular variations in altitude indicate that it is not an old terrace deposit. In many places it is buried under 25 to 75 feet of loess-like silt. In many parts of Maranhão the cementing material seems to have crowded apart grains and fragments of sandstone, giving a kind of breccia or an iron ore with scattered sand grains and sandstone fragments. The process or processes give rise to various striking features—escarpments topped with a palisade wall (see Fig. 6), peculiar boulder trains, low and irregular upland terraces 10 to 50 feet high and fronted by boulders or rock walls that seem to crop up unexpectedly in the woods, and rock or boulder pavements where locally the soil has been washed away.

On September 27 we reached Mirante, a house at the southwest edge of the Serra do Negro. To the southwest we could see some other and smaller table mountains at about the same height. It was the season for burning dry grass, and the air was hazy with smoke; but Serra da Cinta, similar in form and dimensions to Serra do Negro, was clearly visible in outline, 35 miles away. Just northeast of Cinta is a conical outlier peak, Morro dos Friades, which reaches an altitude above 2000 feet.

During the succeeding days we followed a trail running southward toward Riachao, in order to check up a reported occurrence of mica and wolfram. On the whole the country we traversed these days was the roughest seen and had the least developed plains and tablelands. Most of the hills were to the southeast. On September 29 we crossed the Rio Farinha, a tributary of the Tocantíns, 50 to 75 feet wide and four or five feet deep with moderately strong current. We found the forest still scrubby but the denseness to vary considerably. In some places we could not see half a mile, while occasionally from points well up on slopes we could see over the top of the timber 5 to 20 miles.

Eight miles north of Riachao we came to a long descent of about 300 feet from the rocky and sandy upland with buttes and tablelands rising above it to a broad basin excavated mainly in clay shale, extending to and beyond Riachao. Riachao is on the south bank of

a headstream (Rio Cachoeira) of the Rio Maravilha. The streets are loose white sand, and the houses as usual are of clay and sticks or large sun-dried bricks. Foundations are generally of ferruginous sandstone. Extensive inquiries here and along the trail traversed, together with the many good rock exposures, made it almost certain that there is no outcrop of the basement rocks carrying mica and wolfram in this region. Similar inquiries and observations made later at Carolina and in the country traversed indicate that no such material outcrops this side of Goyaz.[8]

To Carolina

We left Riachao for Carolina on October 4. The trail as a whole traverses gently rolling, thinly forested country. All along but mainly to the north there are hills of red sandstone rising to altitudes 600 to 800 feet higher. For the first 30 miles we caught frequent glimpses and some good views of a long table-land of the red sandstone to the northwest with occasional outliers, flat or sharp-topped, and at 15 miles from Riachao passed the foot of a great outlier, Morro Pico. It rises abruptly about 800 feet with sheer cliffs over 200 feet. At 18 miles from Carolina we camped by a fine fall where limestone overlies a calcareous shale. The fall was 50 feet high, a striking and unusual feature in this region.

Carolina is on the Tocantíns River, here a quarter of a mile broad and forming the western boundary of the state. The town is built on an undulating surface 40 to 100 feet above the river. As we have already noted, the town is a commercial center for much country to the west in Goyaz as well as for this portion of Maranhão. It is said that the merchandise brought here annually totals about 20 tons, more than half of which comes from São Luiz by way of the railway to Caxias, by river to Sant' Antonio, and by mule and horseback the remaining 90 miles or so. Salt is an important part of the imports and sells for nearly four cents a pound. The Tocantíns River leading to Pará gets only a small part of the traffic because of its rapids.[9] From Carolina the annual outward traffic includes about 10,000 head of cattle valued at $90,000; 25,000 cowhides valued at $35,000; other hides including about 100 tapir, 1500 caititu, 1000 deer, 100 capivari, and 200 goat. About 5000 quarts of babassú oil are produced annually; about 20 tons of tobacco; and 200 pounds of "ostrich" feathers, which sell for about 75 cents a pound. Cotton growing is just being started, and the yields are heavy. Many kinds of crops do well, but corn and coffee are not extensively grown at present. The region

[8] In geological structure Maranhão is a basin, the Permian, Tertiary, and other rocks resting on pre-Cambrian which outcrops in the northwest and appears again in the west, south, and southeast.

[9] Compare the similar conditions at Boa Vista and Imperatriz, farther downstream, described by S. C. Bullock: Tocantins and Araguaya Rivers, Brazil, *Geogr. Journ.*, Vol. 63, 1924, pp. 369–391.

is primarily a cattle country, and, if some arrangement were made for tiding over an unusually dry season, it seems probable that a vastly greater number of cattle could be raised. The prominent men are eager and hopeful for a railroad, yet general sentiment favors continuation of leisurely development by poor men with primitive methods.

We heard much about the mineral wealth of Goyaz, but prospects about Carolina proved disappointing. There have been attempts to export mica brought from Goyaz, and numerous fragments are to be seen in town. No trace was found of the granite said to outcrop at Carolina. Inquiries were made concerning the new diamond districts in Goyaz across the Maranhão border. That of Pao Secco, 60 miles south of Carolina, discovered in 1923, is estimated to have yielded about 400 carats in 1923 and 800 in 1924. Another new locality is on the Rio Capivari 25 miles farther south.[10]

Carolina to Rio Sereno and Sant' Antonio

From Carolina we started south on the trail for Sitio October 11. For the first few miles the country was rather open and smoothish; ten miles out it became a little higher and rougher but still showed a strong tendency to develop table-lands. About 15 miles southeast of Carolina we came to the Rio Itapecurú which in the dry season is four to five feet deep with slippery and rocky bottom.

On October 13 we reached the Rio Sereno. Here and at several other points along the river hard black bituminous shale is exposed and has been used for torches. It might yield 20 gallons of oil to the ton or perhaps more. The river is about the size of the Itapecurú, and the banks rise about 30 feet above low water.

About three miles north of Sitio we turned east and followed up the valley of the Manoel Alves River. Occasionally the trail crosses sandy stretches and occasionally, like other trails throughout the interior of the state, skirts extensive seepage areas. Also, as elsewhere, small streams are commonly bordered by tall palms and some hard-wood trees from 14 to 20 inches in diameter that would furnish two or three cuts each of saw timber. Such trees stand, on an average, between 100 feet and 200 feet apart. The relief is not high, the tributary valleys being about 100 feet deep. The upland is flat with occasional monadnocks. Farms are about a day's journey apart. Many are occupied by tenants, the owners living in one of the towns. Some owners have 10 or 20 farms, each with its herd of cattle on public range.

On October 16 we again came in sight of Morro Pico, which stands beside the Riachao-Carolina trail, and compass sights to it furnish a check on our position. In this region the timber is comparatively open

[10] The country rocks for both districts are probably undisturbed Permian. Pre-Cambrian with pegmatites outcrops less than 50 miles to the west but apparently not within the present drainage basins of the deposits; possibly there was former access to the basement complex.

except on the narrow bottom lands, and there are some clear openings up to a mile or more across. Occasional views to the south show flattish undulating country for ten miles or more, and people say that there are no mountains in this direction within the state. We decided to spend no more time going south but to continue to the east. On the evening of October 19 we reached Vargem Limpo, lying nine leagues from Sant' Antonio and having about 30 houses. It is in a depression between broad hogbacks trending from a little west of north to south of east. As the trail approaches Sant' Antonio it widens to cart-road size, but only one or two carts were seen.

Sant' Antonio is an agricultural and commercial center on the north bank of the Rio Balsas. There may be over 1000 people living in town, and the municipality is said to have a population of 8420. Freight for points to the west and south comes by water from Flores and thence moves by mule and horseback—the town, like several others, being at the head of small-craft navigation.

About 5000 cattle are said to pass through Sant' Antonio annually. They sell here for the equivalent of $8.00 to $10.00 a head. The cost of driving them through to the coast is about $3.00 to $3.50. The loss of animals en route averages about 10 per cent, and the shrinkage in weight 15 to 20 per cent. Most of the cattle are sent out in January and June. The town also sends out annually about 80 tons of babassú nuts, 500 tons of rice, 15 tons of cotton (just beginning to be raised), 35,000 cowhides, 4000 skins of wild animals, five tons of horsehair, and a half ton of "ostrich" feathers. The soil produces heavy crops of mandioca, rice, and cotton. Corn does not do so well and is not grown to any extent. More than half the soil of the region is flat-lying, free from stones, and in excellent condition for tilling. Tropical fruits, particularly oranges, limes, lemons, bananas, mangoes, bacury, and coconuts, give excellent yields. One coconut tree had 40 nuts. About $300 in taxes are collected on hides, horsehair, babassú, and feathers.

Like other interior points, Sant' Antonio imports much salt, mainly for stock feeding. The salt is coarse and dirty and sells for two and a half or three cents a pound. Salt and other merchandise shipped from the coast arrive in from two to five months after three or four transshipments. Most of the merchandise goes by rail from São Luiz to Flores, thence by boat to Sant' Antonio. There is considerable damage and pilfering loss. It is said that on one occasion a man with a fast boat went to Flores in six days and on to São Luiz in two days more. The freight rate from Flores is about three cents a pound. Mule and horse transportation from Caxias is about a cent and a half a pound and in the opposite direction about four cents, the difference being due to the fact that much more freight is sent in than is sent out, the economic balance being furnished mainly by cattle which are driven out.

FIG. 11

FIG. 12

FIG. 13

FIG. 11—A striking feature of the tabular topography of Maranhão is the sharp angle at the base of the table-land.

FIG. 12—The flat top of the Serra do Negro, showing stunted growth of vegetation.

FIG. 13—View from the Cross at Barra do Corda (see Fig. 8) showing the characteristically level horizon.

Sant' Antonio to Barra do Corda

On the afternoon of October 23 we set out for Barra do Corda, passing diagonally across a terrace about a mile wide and 100 feet above the river, and camped on the north bank of the Rio Cachoeira, or Matapa, having portaged this river and the Maravilha a mile to the south—streams with sand beds and steep 20-foot banks. About ten miles up the Cachoeira there is said to be a large waterfall which gives the name to the stream. A few miles to the northwest is a sugar refinery described as the most modern in the interior. The sugar produced is very fine-grained and not quite white. As at most sugar factories, some rum is made.

About 30 miles north of Sant' Antonio the trail passes into rougher sandstone country with intrusives. The route led up onto a table-land about 2000 feet above sea level, and for 12 miles there was no water. On October 30 we reached the Rio Cassimba, which is the only water and consequently has the only house in 35 miles. It is clear, like most other streams in the state, and is one to five feet deep, 20 to 30 feet across, and the steep banks are 15 to 25 feet high. Here in 1913 there was a massacre of more than 100 cattle-stealing Indians with their women and children.

The last 60 miles before Barra is reached has denser forest but little saw timber. Forty miles south of the town we reached the Corda River, which here has swift water, a shallow channel, low banks, and almost no flood plain. Downstream a short distance the channel deepens, but other features remain unchanged except that malaria is said to be more prevalent. The largest tributary is the Rio Porco about 23 miles from Barra, with water from four to five feet deep requiring portaging. From here downstream the river has cascades and waterfalls for about eight or nine miles, and about 15 miles from Barra there are two waterfalls caused by hard sandstone, in each of which the water drops 10 to 15 feet. On November 5 we reached Barra do Corda again. Here we availed ourselves of the circumstance that a boat was leaving soon for Arary with probable connection to São Luiz.

By River to São Luiz

The river trip was slow and uneventful. As noted above, the conditions along the river do not seem very healthful; and keeping free from malaria is especially difficult. Showers were frequent, but the river was still at a low stage. We again noted the peculiar bars across mouths of many tributaries; the bank-full appearance of the river at many places; the great range in height of banks to Pedreiras, below which the banks are generally 12 to 18 feet high; the gradually increasing breadth of bottom lands; and the apparent high dips of alluvial strata due to the deep channel and its migrations.

At Pedreiras we changed from the little steam launch to a good-sized river steamer. The launches commonly go to Arary, below which the river widens into an estuary whose waves the river steam launches are not built to cope with. In the vicinity of São Luiz Gonzaga at about the head of tide, 130 miles from the coast, there is considerable evidence of silt drowning, and so also in the next 50 or 60 miles downstream. In the last 50 miles several stops were made on account of tide. The tidal range of 15 feet or more gives, of course, strong reversing currents in a network of deep channels near the sea and a tendency to build extensive more or less marshy flats at about high tide level. In places these flats seem to lie at or a little above extreme high tide, whereas in others they are a little below high tide, suggesting recent slight warping. Other features—such as the large and in part intermittent lakes south of São Luiz; the estuaries and *furos*, or tidal channels, of the northwest; a damming of tributary streams; the hills of Tertiary strata on the coast with channels behind them; and, finally, inland hills and other evidences of silt-drowning—all point in the same direction, namely toward recent uplift in the vicinity of São Luiz and depression in a belt lying 50 to 100 miles inland. Whether the two movements have been contemporaneous or successive and what complicating tilting has occurred have not been determined. It is possible, if not probable, that the whole region first underwent differential uplift, greater along the coast, and then differential subsidence, greater along the inland belt.

São Luiz was reached November 25, the river journey taking no less than 11 days.

Summary

Throughout most of the state of Maranhão one may travel by mule back and live off the country in the dry season without much danger or difficulty. Points on the principal rivers up to 200 or 300 miles from the coast are reached most easily by the slow and irregular river boats; and with a private launch these points could be reached quickly, for only the northwesternmost rivers have rapids in their lower courses.

The principal mineral deposits of interest consist of the gold in the northwest, copper at Grajahú, and iron ore and oil shale at numerous scattered localities.[11] For the present the gold seems by far the most important. It is probable, however, that there are undiscovered deposits of value; for only a small fraction of the state's area of some 175,000 square miles has ever been seen by a competent observer.

There are two principal kinds of forest in the state. A belt along the coast 50 to 150 miles wide has a dense growth of small to medium-

[11] See E. W. Shaw, W. H. Wright, and J. L. Darnell, Jr.: Mineral Resources of Maranhão, Brazil, *Econ. Geology*, Vol. 20, 1925, pp. 723–728.

sized trees with a thicket undergrowth of vines, shrubs, and small palms, etc.; a larger area in the interior has more or less stunted timber, commonly without much undergrowth or very low branches, so that one can usually see between trees for a distance of a quarter of a mile or more. In both belts the best timber is along streams, where there are an average of 5 to 20 trees to the acre that measure over 12 inches at the base and would yield from one to three 12-foot logs. Thus, though the state cannot be said to be rich in timber resources, it would profitably support a good many sawmills, for lumber is high-priced and the woods are mostly so hard and durable that small-sized trees can be utilized.

The population, which is largely of mixed blood—white, red, and black—throughout the state seems fairly healthy except for malaria, generally of a mild form, and probably hookworm. The total number of people in the state according to the 1920 census was 874,337. The figure is, of course, an approximation and would seem to be too high. Population is densest near the coast, though no towns except a few small fishing villages front on the open sea, and large areas at all distances from the coast are practically uninhabited virgin forest. All of the larger towns except São Luiz are on rivers, and São Luiz is on an island around which four of the seven major rivers discharge. Practically all houses in the interior are also on streams. The ground-water level is generally not far below the surface, and the abundant sandy beds would yield their water readily to wells. Hence in the future it may be expected that the process of settlement will leave the watercourses and spread over the flatter uplands.

The life of the inhabitants is simple and easy-going. Agricultural development is obviously in its infancy. Less than one per cent of the state is under cultivation at any season, though a very large fraction of the land is arable. The soil is fertile, and crop yields are heavy. It has been shown that cotton will do well in all parts of the state.[12] Rice and sugar cane have long been staple and reliable crops. Mandioca is grown everywhere and rarely fails. Beans, corn, and other products are also readily grown in sufficient quantity for local requirements. Tropical fruits give heavy yields everywhere. Also there are many varieties of wild fruits and nuts, including the important babassú.

The forest is sufficiently open to permit the growth of much grass and herbage. Except for unusually dry seasons there is natural forage for many more domestic animals than are now raised.

Two features stand out impressively. One is that clearings should be brought under permanent cultivation and not allowed to lapse into the wild state after two or three seasons, as is the present custom; and the other is that large clearings tend to reduce very greatly the malarial

[12] A. S. Pease: Cotton in North Brazil, Manchester, 1924.

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ROUTE TRAVERSE IN SOUTHERN MARANHÃO

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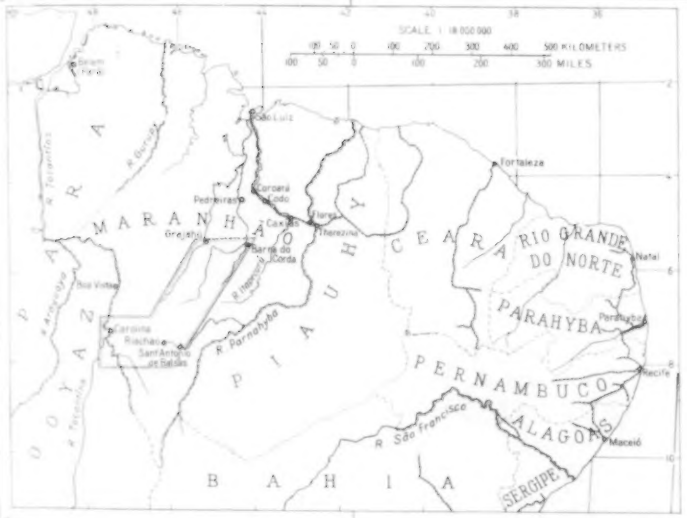
MILES 10 0 10 20 30



Barra do Corda

Grajahú 672

R. Grajahú

R. Mearim

R. Corda

Serra da Cinta

Serra do Negro

Morro Vermelho

R. Farinha

R. Cachimbo

Philadelphia

Carolina 263

Large watershed

R. Ingarcuva

Morro Pico 2000

Riachao 1494

R. Maravilha

R. Tocantins

R. Balsas

R. Serena

Sant' Antonio de Balsas

Intermittent lakes

Vargem Limpo

Route of E. W. Shaw and J. L. Darnell, 1924

Contours in hundreds of feet

Surveyed contours

Approximate

Conjectural

Rivers

difficulty, leaving general health conditions for men and animals excellent for the tropics. It would not be at all surprising if the region should in the near future experience a great development, become recognized as a "white man's country," and begin to support a population several times as dense as that of the present time. The situation invites railroad building—which the general smoothness of the topography encourages—and colonizing schemes. In sum, we may say that the state seems ready for great and rapid development.

Note on Construction of the Map

A pace traverse with Brunton compass and sketch board was made of the route of the party from Barra do Corda to Carolina by way of Grajahú and the return trip by way of Sant' Antonio. The topography covered by the traverse is shown in solid lines on the accompanying map. The elevations of the towns are the averages of several readings from two barometers. Contours were estimated and checked frequently with a land level. A ticker was used to count the mule paces, which were later reduced to feet. These distances, together with the directions as determined by the Brunton compass, were sketched and the notations made as we traveled. The traverse closed within a few miles—a fairly good result for such simple methods. The contours shown on the map as approximate were sketched in as we traveled. The map was edited in the Society's department of Hispanic American research, and the conjectural contours were filled in to give a general picture of the terrain. No astronomical positions were taken, and the traverse has simply been tied to the position of Carolina as plotted on the Therezina Sheet of the Brazilian series of the International Map of the World on the scale of 1:1,000,000.

THE AROOSTOOK VALLEY

A STUDY IN POTATOES

Ella M. Wilson
State Normal College, Ypsilanti

SINCE the nineties the Aroostook Valley in Maine has been famed for the production of potatoes. In 1923 the average yield of all potato fields in the United States was 108 bushels an acre. Aroostook produced an average of 266, better than the German pre-war yield of 209 bushels and much better than the present German yield of 177.

The potato dominates in Aroostook. It is the money crop, an agricultural specialty which, like tobacco in the Connecticut Valley, is the more striking because specialization is not characteristic of New England farming.

Such intensive cultivation is hard to explain, for Aroostook is off the beaten track. The map, Figure 1, shows clearly how far away the people of Aroostook are from the rest of the people of New England and the St. Lawrence Valley. It is an all-night trip from Quebec to the little junction in New Brunswick from which an "accommodation train" crawls the remaining thirty miles to Presque Isle, Maine. By way of Bangor the journey is not so long, but villages are almost as infrequent. On either route, sawmills, lumber camps, log-choked streams, and stands of timber yet untouched dominate the landscape. On either route the train emerges abruptly from forests into garden-like potato fields on gently rolling ridges, and the shacks of lumber camps give place to the comfortable homes of the potato growers.

The Valley and Its People

The appearance of the whole area suggests prosperity and a high standard of living. Along the main roads the farm buildings are in good repair and the yards are well kept. The houses—frame as a rule—are large and rambling with shed and stable attached to mitigate a little the tasks of the cold winters. Ill-kept farms are found only in the hilly, swampy, or more gravelly regions, and they are surprisingly few in number. There are scores of automobiles, telephones in nine-tenths of the farmhouses, and electric lights and washing machines in most of them.

Such an extensive development is the more surprising when it is remembered that Professor W. M. Davis writing about northern

Maine as late as 1899 called it a "forested wilderness" and did not mention Aroostook Valley at all.

Why has there been this sudden development of potato growing in the forests? The climate on the whole is no better for potatoes than in Michigan, Minnesota, New York, or Colorado. The coolness of

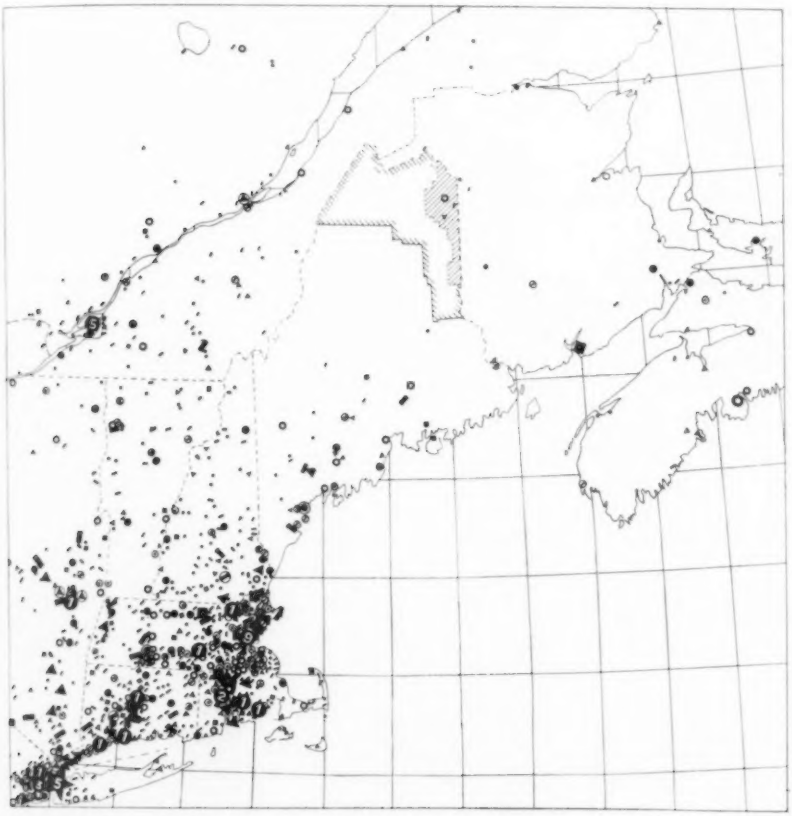


FIG. 1—Map showing the remoteness of Aroostook County from centers of population. To the map, reproduced by permission from Mark Jefferson's "Distribution of People in the United States, 1910," has been added the limits of Aroostook County and of the potato-growing section (the latter from the map referred to in footnote 1). Cities of over 10,000 population shown. Parallels 1° apart.

the summer (mean 62° F.) develops a seed stock hardier than the potatoes that can be produced in warmer climates, but Minnesota says her stock is equally good.

The Aroostook potato region is a pocket of glacial soils in a granitic wilderness. The government soil survey of Aroostook County[1] calls the Caribou loam which predominates an "ideal potato soil." It is a

[1] The "Soil Survey of the Aroostook Area, Maine," *U. S. Dept. of Agric. Field Operations of the Bur. of Soils, 1917* [*19th Rept.*], maps, on a scale of 1 inch to 1 mile, 1090 square miles in the east of Aroostook County—an area practically synonymous with the cleared country.

loose, mellow, silty loam, easy to cultivate and on the whole well drained. But it is a question whether the silty loam soil is any better for potatoes than sandy soil or any other well-drained soil.

Since the climate and soil are not unusually advantageous it seems quite possible that the human factor may have been the decisive one in the development of the valley. The people are chiefly of New England stock—southern Maine Yankee—or of Old England via New Brunswick. The only "foreigners" are the Swedes of the township of New Sweden, who have been in this country since 1871, and the French Canadians in the northern part of the county.

The finest New England traditions are fostered. Almost all the boys and girls graduate from high school; there are good books to read, the churches are well supported, and a lecture course is maintained every winter in the village of Presque Isle with its population of 3500.

Most of the farmers live on their farms. The "hired man" is a member of the family or, if married, lives in the "tenant house" on the farm. Of the thirty farms visited by the writer just one was being run by a man who did not own the farm, and he had been on this same farm for twenty-one years. A man who had lived in the county for many years estimated that one-half of the young men go into business with their fathers or else "work out" on neighboring farms for two or three years until they accumulate capital enough to rent farms. If the renter succeeds, he buys a farm "on time"—usually a twenty-year contract. A young man of good reputation is given every help to make a start. "Nowhere else in the world is it easier to borrow money on character," was the comment of a local banker.

History of the Potato Industry

The slender thread of population that had spread slowly northward in eastern Maine with the growth of the lumber industry reached the bank of the St. John River by 1860. Between 1860 and 1870 the population density along the river increased from 2–6 to 6–18 a square mile—so numerous were the lumber camps. The white pine was floated down the river to build the ships of nineteenth-century fame. Lumber was the money crop. But the men and horses of the camp must be fed, and so were raised hay and oats for the horses and potatoes for the men. The surplus crop, if any, was fed to cattle to sell to the camps. When the camps did not buy all the cattle the rest were driven over the military road to Bangor to be bartered there for farm supplies. In 1868 alsike clover was introduced from New Brunswick, and thus was provided another money crop besides the cattle that were for sale.

Some of the farmers noticed that potatoes grew very well on the ridges cleared of hard wood, but lack of outlet for the crop discouraged

FIG. 2

FIG. 3

FIGS. 2 and 3—Potato fields in the Aroostook Valley. Figure 2, looking over a five-hundred-acre field, shows cultivation on the slopes and ridges, the lowland being uncleared.

any attempt to increase production. The building of the first starch factory in 1871 slightly increased the acreage, but the difficulty in marketing the starch limited manufacture. No railroad reached the region and but one highway of any importance. When the Canadian Pacific Railroad was completed to Fort Fairfield in 1874 the starch industry grew so rapidly that in ten years forty factories were in operation in the county. All of them were small, and most of them ran only during the fall. This industry was well suited to a pioneer community, for it required only a small initial investment and the process was simple.

During this time Aroostook potatoes reached the Boston market, where they were well liked. The importance of improving the transportation was seen; but the farmers of Presque Isle had no money to finance a railroad, and it was not until the late eighties that the business men of Boston could be persuaded to furnish the capital for the Bangor and Aroostook Railroad. When this road was completed in 1890 the starch industry declined. Aroostook now had direct connection with a market that wanted good table potatoes.

The invention of various devices encouraged production—the Hoover digger, by which the acreage was easily increased, and a spraying apparatus. A plan of rotation that increased the crop was stumbled upon at about the same time and was practiced by the more skillful farmers. It involved a four-year program: a year of potatoes, a year of grain, and two years of clover. The clover was plowed under the second year to increase the humus content of the soil. Access to market encouraged Aroostook to put more and more ground into potatoes. The hardwood ridges were cleared, farms were enlarged, stock was sold off, fences removed, and Aroostook County became a potato center almost overnight.

Cultivation Methods

Methods of cultivation are nearly uniform. The fields are on the rounded ridges or on the gentle slopes, rarely on the lowland because it is not well drained. The plowing is done in the fall, and the planting usually in May. The most up-to-date methods of fertilization, cultivation, spraying, and harvesting are followed. The growth of seed potatoes is a specially important phase of the industry. Seed is disinfected before being planted, and throughout seed potatoes are carefully watched for signs of disease. Before the fields as a whole are harvested the potatoes from the best appearing hills are dug by hand for seed purpose. If the whole field passes inspection the potatoes are dug in the usual manner. The more particular growers isolate their seed plots two or three hundred feet away from all other potato fields so that the aphids cannot bring diseases from near-by

infected plots. Two hundred and fifty farmers near Presque Isle had isolated seed plots in 1924.

Digging ordinarily begins the first week in September. It is done with an elevator type of digger usually drawn by a team of horses, although tractors are used on some of the larger farms. Picking is done by hand in order that the small and the decayed potatoes may be sorted out and sent to the starch factories. The contract for this

FIG. 4—Farmhouse on one of the main roads, near Presque Isle.

work is often given to some man who in turn hires laborers for $4 or $5 a day. The contract price is from eight to thirteen cents a barrel. A man can pick up from fifty to one hundred barrels in a day.

All farms except the poorest have the same type of "potato barns"—wooden storehouses with concrete or masonry basement walls. They are built on sidehills with a front entrance to the barnlike upper story and a back or basement entrance to the storage cellar. The storage cellar usually has a wooden floor built over cement and is well ventilated. In severe weather it is heated by a wood stove placed near the coldest spot—the door. The floor above is ordinarily used for storing the empty barrels and farm implements although it is sometimes used for hay. The smaller storage barns hold 2000 barrels, the average-sized hold 5000 barrels, and the larger ones hold 10,000 to 12,000 barrels. On the poorer and smaller farms or on some of the farms close to the railroad there are no storage facilities, the potatoes being hauled directly to the storehouses at the shipping points.

In the matter of rotation of crops there seems to be no general systematized procedure. Most of the farmers do not rotate consistently. One field observed had been planted to potatoes continuously

for twelve years with no increase in the amount of fertilizer. The plants were vigorous, and the potatoes clean and well shaped. The acre yield, however, was twenty-five barrels less than the average—a decrease that meant loss and not profit in production. In general, without a rotation including clover, the soil becomes baked and lumpy; and the potatoes are dark, rusty, and veined.

Costs of Production

The production of the crop involves a large expense. Land on the main roads is valued at $150 to $200 an acre. The renting price of a farm is based on the amount of potato land it contains. Thirty dollars an acre is paid for this, and the rest of the farm is thrown in. Choice potato fields rent for $35 an acre. Farm wages are high. A man who works by the year is paid $20 a week. If a house is furnished, the wage is $17; and if both board and room are furnished, he is paid $12. A foreman on a farm receives about $30 a week.

Fig. 5—Farmhouse with shed and stable attached.

The machinery is expensive, and it costs $2000 to build a small potato house. In 1924 fertilizer cost $58 a ton on the average, and a ton was put on every acre of potato ground. The treatment of the seed costs 15 cents a barrel, which with the cost of spraying and digging increases the total. An investigation covering 92 farms aggregating 2348 acres showed that in 1923 it cost almost 51 cents to produce a bushel of potatoes without counting storage or shipping. The acre cost was nearly $142. If the potatoes are stored, there is a depreciation of about ten per cent from shrinkage, frost injury, and decay.

To meet such high production costs there must be a high yield and efficiency in salesmanship. The Presque Isle farmers know how to produce—their high acre yields year after year show that—but until 1923 they had paid little attention to the selling end of the business. Until that time the marketing was done through the growers themselves, through local buyers who bought to resell, and through outside buyers who represented chain stores or commission houses. Some five or six large growers did the bulk of the business. They bought both seed and table stock of the small producers, graded

it, and stored it until the market was favorable. In 1923 a single company purchased 1625 carloads of potatoes from the Presque Isle district. One hundred cars were of seed stock to supply the village stores in Massachusetts and Rhode Island for their customers who had "back-yard farms." This firm spent $952,000 in Aroostook County for potatoes, labor, and rent.

In 1919 the price of potatoes soared so that some growers received as much as $10 a barrel. Then came three years so lean that many farmers did not sell their potatoes for enough to pay the freight bills and many could not sell at any price. Out of a desire to improve this situation the Maine Potato Growers' Exchange (a non-profit coöperative marketing association) was organized in 1923. The overproduction of the succeeding year, however, led to disbanding in 1925. While the Exchange was in existence all growers profited by the steady prices resulting from the elimination of speculative marketing and from the orderly marketing of approximately one-ninth of the crop every month.

FIG. 6—A small potato storehouse.

All of the potatoes marketed are shipped either by the Bangor and Aroostook Railroad or by the Canadian Pacific, to which the Aroostook River Railroad acts as a feeder. Last year the Canadian Pacific Railway shipped 6861 cars from Aroostook County, and the Bangor and Aroostook 22,724 cars—24 per cent and 76 per cent respectively. The freight rates are uniform, 39.5 cents a hundredweight to Boston; 55 cents to New York City, and 72 cents to Long Island. In spite of the improvement in methods, the high marketing cost—about ninety-two cents a barrel—is a serious handicap. The people who eat the potatoes live a long way from the people who raise them.

DOMINANCE OF THE POTATO

To this handicap must be added the hazard of one-crop production. Although in Aroostook County there is ordinarily a larger acreage of hay than of potatoes, with oats a close third, the potato is the money crop and as such is the controlling factor in the farm procedure. Nine farms selected at random in the Presque Isle section and containing 3711 acres had in 1924 1738 acres, or 47 per cent, in potatoes; 629 acres, or 17 per cent, in oats, wheat, buckwheat, and clover; while the remainder was in unimproved pasture or wood lot.

In general, the farmers raise enough oats to feed their horses, and in good years there is a surplus of hay to sell. Buckwheat is raised to feed hogs, for all the corn used has to be shipped in. Each farmer tries to raise enough wheat for his year's supply of flour. Hogs, poultry, and sheep are very incidental sources of income. Of twenty-five farmers interviewed just one was sure of the number of his pigs, and not one was sure of the number of hens or turkeys raised. No one kept poultry accounts, and no one had attempted to cull the non-layers. There are not enough eggs to supply the local market, and the county has just one hennery. One store in Presque Isle ships in 120 dozen eggs a week; a second ships in 300 dozen eggs of the 800 dozen it sells each month; and a third ships in not quite half of all it sells.

This section is a deficiency area for dairy products also. There are four dairy farms near the village of Presque Isle to supply the local demand for milk; but there is not a creamery in the county, and at least a third of the butter is shipped in. Of the many farmers interviewed, one had a pure-bred herd. Of the others few were making much of an attempt to improve their stock.

With horses the story is a different one. Almost without exception the horses are high-bred Percherons. Horses are important in the farm economy, for they—not tractors—do the work in raising potatoes. But even they are not all raised here. Most of them come from Ohio.

Several farmers have a few sheep, and three have flocks of 35 or more. There is no slaughterhouse in the county, although there is one man who earns his living by doing butchering for farmers that do not do their own. The orchards run wild with the exception of three, which were well cared for and yielded well. One man had 100 hives of bees and was the only farmer in the township that produced honey to sell.

Potatoes dominate the food supply as well as the farm culture—a situation not always so in a one-crop region. The farmers of Denmark find their butter too precious to eat. They sell it and eat margarine. Poultry raisers use few eggs. But potatoes are served three times a day in Presque Isle. Seven large ones were an individual serving for a Sunday dinner! And they were excellent potatoes. It is cheaper to eat potatoes than anything else. Food shipped in is expensive because the freight rates are so high.

Diversified farming is preached but rarely practiced. Even the Farm Bureau and the Federal and State Farms limit their investigations to those concerned with the improvement of the potato crop. Farmers were agreed that grain could not be raised in competition with grain from the West with a freight rate of 32 cents per hundredweight to Bangor. Sugar beets had been tried by a few but had not done well. Some farmers thought peas might be successfully raised

for canning, but no one had tried to find out. Nothing but potatoes interested them.

Even lumber has ceased to be a source of revenue. Most farmers clear about one acre a year to supply fuel for home use and for the potato houses. Good hard wood is so scarce near the villages that sixteen-inch lengths during the winter of 1923 sold for $16.50 a cord delivered. The large stands of timber in the western part of the country belong to corporations that are holding them for pulp and lumber purposes, and they sell very little for fuel.

Several defended their one-crop system by saying, "We want to raise a crop that will give us a quick return for our labor; we don't want to wait for a calf to grow into a cow." Another said "I want to raise a crop that gives me leisure time. I spend my winters in Florida, and if I had any stock I'd have to stay at home to care for it."

One-crop farming here as elsewhere means financing the crop on credit. Of the 3100 farmers in the Exchange (1924) 1320 had crop mortgages. Several business men said that at least half the farmers had mortgages on their land and that nine out of ten of them had to have credit of one kind or another. The merchants expect to carry the farmers through the summer months; even the telephone company gives three months' credit to its rural patrons, and practically all of the fertilizer is sold on time. As in the cotton belt, when a good year comes debts are paid and improvements are made; and when the crop cannot be sold credit is extended another year, and buying of everything but necessities is curtailed.

Conclusion

Aroostook farmers do not fear crop failures. With true Yankee shrewdness they have learned to produce year after year more potatoes to the acre—309 bushels in 1924—than any one else in the United States. Now this same wit must be employed to solve the problem of how to use and dispose of large crops at a profit. Markets are remote. The growers of Long Island, New Jersey, Michigan, and New York are much more advantageously located. Coöperative marketing will help but is not a panacea for a glutted market. Quality production and specialization in seed stocks compensate somewhat for high freight rates, but Minnesota farmers are specializing too.

A small part of Maine's surplus—357,500 bushels in 1924—was converted into starch. There would, of course, be a smaller surplus if supply crops were raised instead of so many potatoes. With typical "Old World" thrift, the Swedes of Aroostook County have orchards, bees, berries, and gardens as well as oats and potatoes. They have no bonanza years and no years of failure. Their houses and farms are smaller, and so are their mortgages. In 1924 there was just one farm mortgage in New Sweden and not a crop mortgage.

IN THE NORTHWEST OF THE AUSTRALIAN DESERT*

Frederick G. Clapp

[With separate map, Pl. II, facing p. 230]

TRAVELERS across Australia by the Transcontinental Railway are accustomed to refer to the barren flat salt-bush and blue-bush country as a "desert" throughout the area known as the Nullarbor Plain. The region along the telegraph line from south to north in Northern Territory is likewise sometimes spoken of as a "desert." Prospectors who go northeast from Perth to the vicinity of Wiluna talk of visiting the "desert." Cattlemen who in favorable seasons have crossed the narrow sandy belt known as the "cattle route" between Wollal and De Grey River have "crossed the desert." Yet none of these regions constitutes "*the* desert" as the term is commonly used by Commonwealth geographers. In the January number of the *Geographical Review* Griffith Taylor[1] defined as "Western Desert" an area of over 400,000 square miles south of the Kimberley region of Western Australia. It is with the northwestern border of this region that the present paper is concerned.

Exploration of the Desert

The map, Plate II, shows the country discussed. On the seaward margin are the great cattle stations characteristic of this land of magnificent distances. An American rancher would find it a novelty to travel on his own land for 100 miles without leaving it, but such is not the case in Western Australia. It is, however, in the coastal belt that the population dwells: the interior has no inhabitants save the dangerous and treacherous blacks. The so-called "Great Sandy Desert" has been traversed by only a few explorers, and two large areas are still absolutely unknown. Next to the absence of water the presence of sand hills is considered the greatest source of hardship in the desert. It is certainly true of the sand-ridge country of northwestern Australia. The persistency of the ridges over hundreds of miles, their lifelessness and deathly quiet are impressive beyond words.

*This paper was written with the permission of Mr. Albert Edward Broué of Sydney, N. S. W., under whose instructions the Westralian explorations—the "Kimberley Oil Expedition,"—were made as a phase of the world-wide quest for oil.

[1] The Frontiers of Settlement in Australia, *Geogr. Rev.*, Vol. 16, 1926, pp. 1–25.

The first crossing of the interior[2] was made by Colonel Peter Egerton Warburton[3] in an east-west direction in 1873. Since then it is only known to have been crossed six times. Warburton visited Oakover River, Joanna Spring (200 miles in air line southeast from Broome), Gregory Salt Sea, and points in Northern Territory. In 1897 Hon. David Wynford Carnegie[4] traveled north from Kalgoorlie across the desert to Halls Creek, 370 miles east of Broome, thence back to Kalgoorlie. The Calvert Expedition under L. A. Wells went from south to north in longitude 124° E.[5] It was near Joanna Spring that two members of the party lost their lives. In 1897 Rudall, on a search expedition for the missing men of Wells's party, explored portions of the desert for 170 miles east of Oakover River, and Nankaville visited the same country in 1922. In 1906 Ankatell traversed from Lochinvar Station near Warrawagine Station on Oakover River east to Joanna Spring. The Canning Stock Route was surveyed in 1906–1907 from the vicinity of Wiluna in latitude 26½° northeast by way of Lake Disappointment, Lake Auld, and Godfreys Tank to Halls Creek. It is discussed in detail by Talbot.[6] In 1922 Leo Jones made a geologic trip across the Canning Stock Route, resulting disastrously to his companion who was murdered by blacks.

The writer's party sailed from Fremantle, the port of Perth, on April 13, 1924, bound for the north, the land where no Australian goes unless on business and which foreigners seldom visit. In the north of this great state of 332,000 persons[7] (of whom 155,000 live in the city of Perth) there is a white population of only a few thousand. The majority of the passengers landing at the various ports were "squatters," as the station owners or ranchmen are called, or their families who go south for the summer and return in the autumn.

Broome and Its Environs

The expedition disembarked at Broome. The town is on low land, without appreciable relief except for immense sand dunes rising behind it, and stretches out over a mile, with streets broad and sandy, lined with trees, often nearly deserted. The population consists of a few hundred whites and several thousand "colored people," aborigines and Asiatics, among whom are a large percentage of Japanese.

[2] The Sturt Creek area in the extreme northeast, visited by A. C. Gregory in 1856, is not included in the discussion.

[3] P. E. Warburton: Diary of Colonel Warburton's Exploring Expedition to Western Australia in 1872–73. Adelaide, 1875; *idem:* Journey Across the Western Interior of Australia, London, 1875.

[4] D. W. Carnegie: Explorations in the Interior of Western Australia, *Geogr. Journ.*, Vol. 11, 1898, pp. 258–287; *idem:* Spinifex and Sand: A Narrative of Five Years' Pioneering and Exploration in Western Australia, New York, 1898.

[5] L. A. Wells: Abstract of Journal of Explorations in Western Australia, 1896–7. *Proc. Royal Geogr. Soc. of Australasia, South Australian Branch*, Adelaide, Vol. 3, 1899, pp. 147–171.

[6] H. W. B. Talbot: Geological Observations in the Country Between Wiluna, Hall's Creek, and Tanami, *Western Australia Geol. Survey Bull. No. 39*, Perth, 1910.

[7] Excluding probably 26,000 aboriginals.

FIG. 1.—One of the minor sand ridges on the northern border of the desert.

The town forms the center of the pearl-fishing industry of northwestern Australia, this business being largely in the hands of Japanese, who conduct it in the name of Australian dummies, since by law Japanese are not allowed to engage in it. This business began 30 years ago with naked divers, mostly aboriginals; in recent years as many as 3500 men have been engaged in pearling—mostly whites and Asiatics; but the actual diving for pearl shell is the brown man's business. The work of pearl fishing extends up and down the coast for hundreds of miles in water up to 26 fathoms deep. Broome has little other business, since there are tributary to it only about half a dozen cattle stations—the climate is considered too hot for sheep raising on a large scale.

On April 27 after several days' delay the expedition—four men and two dogs—started out on the first stage of the desert journey, by tractor loaded heavily and dragging behind a trailer carrying an equal weight.

Three roads lead out of Broome. That to the north extends only to Beagle Bay Mission and several small cattle stations in Dampier Land, as the peninsula west of King Sound was formerly called. Another road leads east to a ranch known as Roebuck Plains Station, 22 miles distant, thence to Derby, over 100 miles away on King Sound. The third road stretches south to Edgar Station, Lagrange Post Office, Anna Plains Station, Wollal, famed as the headquarters of a recent eclipse expedition, and Port Hedland. None of the roads can be called good, although all are passable by motor in dry weather. The expedition took the second road mentioned, i. e. to the Roebuck Plains Station where the party was invited to breakfast at the Male homestead, the first and last house between Broome and the desert. Some ten miles farther inland the first camp was established at a site known as Coolmakop.

Topography of Western Australia

The topographic features of Western Australia have been classified[8] as (1) the Coastal Plain; (2) the Hill Ranges, and (3) the Interior Plateau.[9] The width of the Coastal Plain is nil in places between Port Hedland and Onslow but expands to 100 miles or more in Gascoyne District of Northwest Division. Between Broome and Wollal this plain merges with the Interior Plateau so gradually that no boundary can be pointed out, and the Hill Ranges are missing.

[8] A. G. Maitland: A Summary of the Geology of Western Australia, *Geol. Survey Memoir No. 1* (Ch. 1, Mining Handbook), Perth, 1919, p. 5.

[9] The Coastal Plain is considered as practically synonymous with the area of Tertiary strata, though some country topographically belonging thereto is of Jurassic age, and other inconsistencies exist, such as the "Cape Range" of Tertiary strata, between Indian Ocean and Exmouth Gulf. Such ranges as Kennedy, Carrandibby, and others in the Murchison and Gascoyne districts of Northwest Division and Dampier and Edgar Ranges in Kimberley Division are topographically part of the Interior Plateau and of Permo-Carboniferous age.

The writer's observations lead him to the opinion that the term "Great Plateau," or "Interior Plateau," should be used cautiously, for it merges on the west with the Coastal Plain; and even in areas more than 100 miles into the interior, midway between Dampier Range and De Grey River, the so-called "plateau" was found to be within approximately 300 feet of sea level.[10]

In places the bush, or forested area known as "pindan," comes close to the sea. Other coastal sections consist of broad marshlike plains, rarely covered by the highest tides, only a foot or two above sea level, as flat as a floor for many miles, reported sometimes covered with luxuriant grass, but often found to be without vegetation except for a low samphire plant, juicy and useless, and occasional salt bush. Sometimes rich growths of grass are found far distant from any wells about which cattle are pastured. In composition the plains are clay but are underlain throughout large areas by late Tertiary or Recent cavernous limestone. The plains are generally strewn with shells belonging to recently living species. This fact and that of numerous dead trees standing below sea level in places along the edges of certain marshy tracts attest sinking of the land in recent decades.

Back of Broome these open clay plains extend with an irregular boundary for many miles, backed by apparently flat sandy bush country, the surface of which may ascend to an altitude of 50 feet or more within five miles. Similar plains, alternating with low bush, extend for many miles north of Broome and several miles back from the coast. They were also seen near Beagle Bay, in the vicinity of which evidences of subsidence are most obvious in the form of patches of dead timber below high tide level. South of Roebuck Plains the same open marshes recur frequently all the way to Anna Plains Station, 140 miles to the south, and in this interval comminuted shell and sand deposits are sometimes found in the form of abandoned but very recent sea beaches.

The most conspicuous characteristics of these sea-level plains appear to be the extreme irregularity of their border and the fine silty clay consistency, whereas the adjoining bush country, or pindan, is a gently sloping or rolling sand surface.[11] Where the sea-level plains adjoin the pindan large white cajuput or paperbark trees are common. They appear to be significant of the presence of water not far from the surface: in the interior and higher portions of the bush country they are seldom found. The borders of the plains, where mixed with light sand and adjoining the bush, are often dotted with ant hills, 2 to 20 feet in height, characteristic of the northwest.

[10] F. G. Clapp: A Few Observations on the Geology and Geography of North-West and Desert Basins, Western Australia, *Proc. Linnean Soc. of New South Wales*, Sydney, Vol. 50, 1925, pp. 47–66.

[11] The sea-level plains are of Recent age, and the pindan sands are considered Pleistocene or late Pliocene, although underlain at moderate depth by Jurassic or earlier rocks. The term "pindan sands" was given by Hardman, who long ago explored the adjoining region to the north (E. T. Hardman: Geological Map to Accompany Report on the Geology of the Kimberley District, West Australia, 1885).

FIG. 2

FIG. 3

FIG. 2—Coastal sand dune near Broome.
FIG. 3—The north escarpment near its western, or lowest, end.

It was in this border region that we pitched our first camp, at Coolmakop, where a large plum tree furnishes shade. Natural facilities consist of well, windmill, and a trough for cattle and one for sheep, placed on opposite sides of a barbed wire fence. Neither here nor at other camps did the party regularly sleep under canvas. Only one minor shower took place, on May 9. The ground was scarcely wet, and this was the only rain experienced from April 27 to October 13. The expedition was rendered difficult by being undertaken at the close of a second year of almost continuous drought. Rain gauge readings at one station showed a precipitation of only about 2 inches

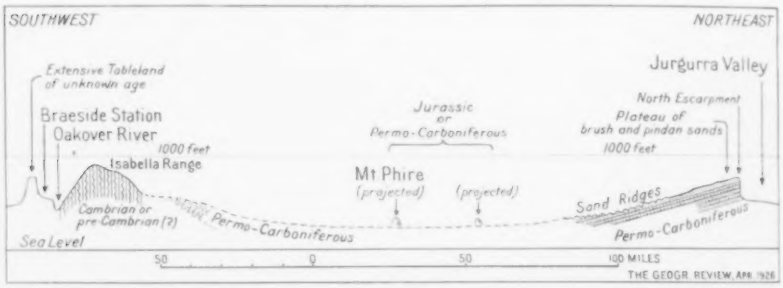


FIG. 4—Generalized section across the Desert Basin (see Pl. II) from the Oakover River to the Fitzroy lowland.

in 1923 instead of the expected 12 to 16 inches, and other stations showed similar results.

In the evening wallabies and kangaroos surrounded the camp by hundreds. Out in the plains during the day were flocks of a tall white species of heron known as "native companion," while in the cajuput and gum trees surrounding the camp were numerous song birds, refuting a statement often credited to English school geographies that "Australian birds have no song." Often bright red and green cockatoos were about with their cheery voices penetrating the air. The worst feature of this and other camps was the host of pestiferous flies. They were never absent during daylight hours even far into the barren region known as the "desert" where cattle never stray and where all bushmen had declared no flies could live.

THE GREAT PINDAN

The country in the vicinity of Coolmakop is better provided with water than any other section visited. A mile distant is "Chain well" while two miles to the southeast is "Pindan well." At Chain well a family of blacks, the last half-civilized aboriginals seen towards the interior, was found pumping the daily supply of water into troughs for the cattle. Other wells exist four miles northeast of Chain well at

the Streeter homestead on Roebuck Plains Station, but the trail does not pass this house. The wells in northwestern Australia are seldom so closely drilled as they are in this little area of a dozen square miles, and beyond Pindan well no surface water exists for ten miles. The country is gently undulating sand, and in places, as five miles southeast of Chain well, it reaches an altitude of 200 feet, instrumentally determined, while 20 miles southeast of Chain well it attains an altitude of 400 feet.

From Broome to Chain well the country is fenced at intervals, and four gates are entered in that distance, two more being reached in the

FIG. 5—View in the fringe of cajuput (paperbark tree), between open sea level plains and dense pindan. Near Broome.

first four miles beyond Chain well; and the last fence is situated six miles from Chain well, or 37 miles from Broome. In the "never-never," or country beyond to the east, there is no fence for at least 1000 miles. Beyond the fences stray cattle are allowed to roam freely in all directions, recognizable to their owners only by brands, and a few cattle were seen in the more open sections as far as 100 miles out of Broome and 60 miles beyond the last fence. Although cattlemen in this part of Australia naturally claim their own property and any seizable unbranded cattle, they recognize the right of explorers or prospectors to kill "cleanskins" (unbranded cattle) for their own use.

The wells mentioned lie on the edge of a vast forest of pindan, extending south and east for 100 miles which, except on the route followed by this expedition, has never been penetrated. The pindan, like most of the bush in this part of Kimberley Division, consists of shrubs and many varieties of trees such as wattles, ti tree, beef bush, a native "plum tree," ironwood, quinine bush, bloodwood, and varieties

of gums or eucalypts. The trees average 10 to 30 feet in height. Plenty of grass suitable for cattle is evident in the more open portions, but the brushy portions are too dense for cattle, even if water were available.

Beyond Hamiltons well, 42 miles from Broome, repeated stops were necessary for "making road" by the removal of fallen trees and the digging out of stumps. The small projecting remnants of broken stumps of brush or trees burned over by the aboriginals in past decades penetrate the pneumatic front tires of the tractors like points of steel, and many were the punctures which it was necessary to repair. In places the roadway had grown up to trees an inch or more in diameter, and axes or hatchets ("tomahawks," as they are known throughout Australia) became essential to our progress over a distance of 150 miles. Beyond the 75-mile point[12] no vehicle had previously traveled, and the road throughout nearly every rod of the distance was cut by hand through the dense pindan. The sandy surface made going difficult for the tractors, and deep ruts were quickly worn by the caterpillar bands.

North Escarpment of the "Great Plateau"

The North Escarpment of the Interior Plateau constitutes a vast and spectacular geographical feature. Commencing 77 miles southeast of Broome, or 35 miles southeast of Hamiltons well, the escarpment first appears as a mere dropping of the surface below the level of the pindan sands, which slope gradually upward from the inner edge of the sea-level plains near Broome. The sands have an altitude above sea level of 600 to 800 feet on the plateau escarpment, which itself attains a height of 100 to 300 feet above the immediate level of the great valley to the north that forms part of the Fitzroy lowland. Some low hills near the rim of the scarp rise a few feet higher than the general plateau level, hence the designation "ranges" given by the Northwest bushmen on account of the appearance of the escarpment as hills when seen from the east and north. The escarpment and "ranges" consist of massive white sandstone eroded at the outcropping edges into extremely irregular features similar to the "breaks of the plains" familiar to Texans on the eastern edge of the High Plains. The escarpment first appears a fraction of a mile south of the trail and extends out of sight to the southeast. "Dampier Ranges" is the name that has been suggested to distinguish this high land at the extreme western end of the escarpment from Edgar Ranges, situated farther east in the vicinity of Jurgurra (popularly named "Jeegully") Creek.

[12] Up to this point a road was cut years ago by Messrs. Tighe, King, and Chamberlain, who planned a cattle station in the back country.

FIG. 6

FIG. 7

FIG. 8

FIG. 6—The north escarpment of the plateau, looking south.
FIG. 7—Mt. Owen, an outlier of the plateau, near Big Spring (Camp 3).
FIG. 8—Twin Buttes, an outlier of the plateau near Camp 4.

At the point where the ground begins to drop eastward a supply depot was established and named the "Junction," because here our route south on top of the escarpment diverged from the old trail which can still be faintly discerned for a few miles farther east. The first trip of the writer on this trail was made in a Ford while awaiting repairs to his tractors. On only one previous occasion had an automobile penetrated so far from the coast. The occupants were searching for a reported coal occurrence; but the car broke down, and they nearly starved to death on their trip back afoot. No white men live in that part of the interior; and only two or three white bushmen, who go to round up cattle which have strayed from coastal stations, have any business so far inland.

The escarpment extends southeast many miles from its northern extremity, then turns east, forming an irregular line of cliffs—vertical and inaccessible to a vehicle at any point, rarely scalable by man, and the crest accessible to horses only at points dozens of miles apart. Judging from verbal reports, the cliffs extend east for nearly 200 miles and may constitute a repetition of certain table-lands described by Carnegie, Talbot, and others in the vicinity of the Canning Stock Route. About the 123rd meridian numerous "breakaways," or canyons, indent the plateau for miles back of the escarpment proper, so that it is impossible to travel in a straight line on the edge of its crest. Very few aboriginals live on that part of the plateau.

The country north of and below the escarpment is quite different from that traversed to the west and is still different from that to the south on top of the plateau and crossed by this expedition. The north country lies low and is flat or rolling, sandy, but with some "clay pans" which hold water for long spells after a rainy season. It has much brush, but as far as was observed is nowhere impenetrable. Traverses by tractor for miles along the base of the escarpment to the southeast revealed comparatively good going. Having heard of the "cattle yards" a few miles east below the escarpment and expecting a considerable encampment there, one was hardly prepared to find on arrival that "cattle yards" in the Northwest constitute what would be called a small corral in the American West.

Waters of the Escarpment

Never in the course of the exploration was appreciable water found on the plateau except in large potholes (known as "rock holes") situated at the heads of valleys or "breakaways." The holes generally contained between 5000 and 20,000 gallons of pure potable rain water. Some lie in shallow valleys near the brink of the plateau crest, others in the breakaways at its base. An example of the latter is Big Spring, several miles from the western end of the escarpment. In

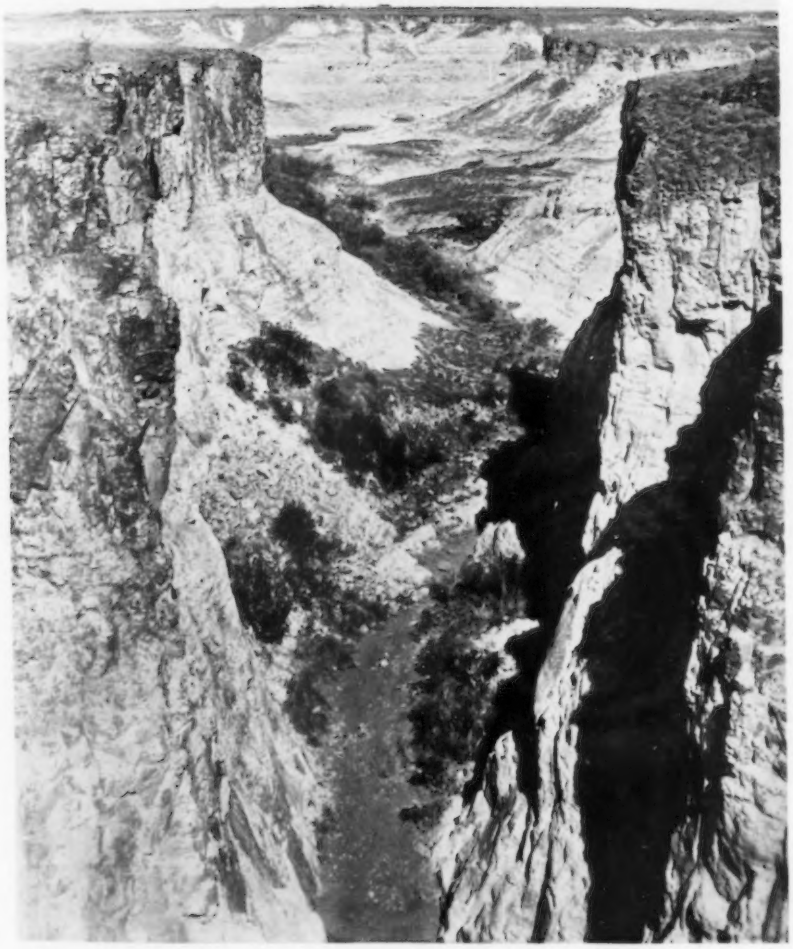


FIG. 9—Royal Gorge, looking northeast from Camp 9 towards the front of the plateau near the head of Jurgurra Creek.

reality this is not a spring at all, for it is only replenished for a time by seepage through crevices from another rock hole higher in the breakaway. Big Spring was the only water in which fish were still living, and no real springs were seen at any point in the Kimberleys south of Beagle Bay.

Big Spring furnished an ideal spot for Camp 3, selected as headquarters while we were surveying and cutting a road to the plateau crest. Camp was pitched in a grove of pandanus palms, scrubby trees 20 feet or more high, recognized throughout the Northwest as a certain sign of water at shallow depth. The cliffs close in so that the valley, forming a reëntrant angle in the escarpment, becomes only a few hundred feet wide.

FIG. 10—The water hole at Camp 9.

It is impossible to estimate the number of water holes on the escarpment. Probably many of them are full during an ordinary season, but so many were dry in 1924 that it was necessary to travel many miles to find them. Probably a dozen waters were discovered in the 60 miles of the escarpment traversed.

South of the escarpment no waters were found. Springs are reported on the extreme east end of Anna Plains Station, 40 miles east of a homestead of that name and 140 miles south of Broome, but they have apparently been visited by white men only on one occasion. In fact, the eastern extremities of stations fringing the coast are practically unknown to the whites. Likewise nothing is known to the writer of waters along the southern margin of the plateau basin or desert; it is probable that they are not common in dry weather, for a camel driver refused to enter that region in the latter part of 1924, at the end of the second year of drought.

Waters in the desert are mainly of the sort known as "native soaks," i. e. places where water sufficient for a few families is obtained by digging by primitive means, and such waters are fairly common at the end of an average rainy season. The rainy season coincides with the summer months, when the weather is hot and traveling difficult. Carnegie and Warburton proved the possibility of crossing the desert

during an ordinary summer—though Warburton nearly perished in the attempt—but they could not have succeeded in the winter or dry season of 1924.

The coast region is watered by dug wells, 30 to 100 feet deep, often pumped by individual blacks hired to camp with their families close by and furnished with clothing and a few other luxuries, such as flour and sugar, as payment. With the exception of wells on Canning Stock Route, however, the well farthest from the coast is Hamiltons—a government well 80 feet deep sunk years ago; and without it no water exists in times of drought between Pindan well and a clay pan, or lowland water hole, north of the west end of the escarpment 50 miles southeast.

Ascent to the Escarpment Crest

A sufficiently easy grade for ascent of the plateau by the tractors was found at the western end of the escarpment; and two entire days were spent by three whites and a black boy in laboriously cutting a road through thick pindan far enough back from the escarpment so that no breakaways would be encountered. After some search a fine water hole was located and selected as the site of Camp 4.

A "bushman" in Australia is proverbially the highest type of frontiersman, unflagging in zeal and activity, fearless and able to surmount all difficulties. After months of experience in the Northwest I am obliged to admit the impropriety of the term "bushman" for the type of frontiersman now covered by the term, for he is really a cowboy. He can ride a horse to perfection, round up cattle and camp for months by living on "damper" and beef; but, as more than one of them remarked personally, he would "rather die in the desert than walk back to civilization." Perhaps it was for this reason that my Northwest bushman persisted in taking his black boy along on all scouting trips, for the boy could have returned for relief if necessary. The writer prefers in general to rely on his own resources and to reserve any available space in the car for water and food for geologist and driver, but it seemed best to defer to the guide who had been engaged to find the route. The black boy, Yumba, was a necessary evil, speaking no English, not even adept at finding the springs along the escarpment, and lazy, like all Northwestern aboriginals. When we were south of the escarpment a watch was maintained every night in four-hour shifts from nightfall to sunrise. As an additional protection a dog was taken along.

The outlook north and northeast from the escarpment is spectacular, especially at sunset, for sunsets in the Kimberleys are brilliant. In the near distance from Camp 4 stand two outlying remnants of the table-land, which we promptly named Twin Buttes; and somewhat nearer to Camp 3 stands a broader table-land known to cattle-

men as Mt. Owen. On clear days several great sandstone outliers far in the northeast also are visible. One prominent pinnacle is known as Goorda Tower, other less pointed peaks are Mts. Alexander and Jarlemai and Babrongan Tower. The headwaters of Jurgurra Creek emerging from the plateau escarpment are surrounded by these flat-topped hills and other outlying table-lands known collectively as Edgar Ranges.

The nights on the escarpment are wonderful, dry and with phenomenally brilliant stars, the Southern Cross standing out in all its glory—a symbol of the great Commonwealth whose flag it embellishes. The best thing about the nights is that they constitute the only respite from the ever-present flies.

Southward on the Plateau

A southerly course was now necessary to avoid canyons, or breakaways, which extend far back from the normal edge of the escarpment. After crossing a few miles of open sand plain dotted with gum trees, the first of the breakaways south of Camp 4 was seen to the east, being apparently a western tributary of Jurgurra Creek. On the forenoon of the second day out from this camp a new water supply (estimated at 17,000 gallons) was discovered in a rock hole on a sightly spot above a white sandstone canyon 160 feet deep, 20 miles or more back of the escarpment proper and over the head of which water must pour in a veritable cataract in time of flood. This canyon, with its vast panoramic maze of hills and valleys extending to the north and east, might have been in Wyoming or Arizona. It was christened "Royal Gorge." On the plateau above, Camp 9 constituted headquarters for several weeks while we were cutting road, exploring the vicinity, and scouting to the south.

On July 13 the first blacks visited the camp—first a woman, then an old man, followed by others dropping in one by one, until half a dozen had accumulated who frequented the camp for a few days. They spoke no English but asked first for tobacco, then bread. They wore no clothes except that the "gins" had a scant skirtlike garment. They brought no weapons into camp, having deposited them on the edge of the bush a mile or two distant, where they were awaited by other members of the tribe, sometimes seen through field glasses.

Proceeding south from Camp 9, the party penetrated four miles of dense brush surrounding the head of breakaways and proving harder on the tires and caterpillar bands than hundreds of miles of sand. As we emerged from the brush the scene changed to a fine open country, with some desert gums and a growth of spinifex and ordinary grass, frequently burned over in the past, beyond which no cattle were seen and none are believed to graze so far from the coast. The

FIG. 11

FIG. 12

FIG. 11—Going south towards the sand ridges from Camp 9.
FIG. 12—Going south over the first sand ridge.

good going lasted a few miles only, then an increasing proportion of spinifex, in places tufty and rough, and brush was encountered. Later many days were spent in cutting a road, digging out stumps, then bringing up sufficient gasoline and water to move headquarters farther south.

On July 15 a start was made in an effort to reach Joanna Spring, and by dint of hard work 69 miles were covered in three days. For miles the method of road making resorted to for the return trip was ruthlessly to set fire to all vegetation passed, and the flames and smoke from miles of spinifex fire rose skyward, visible for scores of miles.

The Sand Ridges

The first sand ridge was reached 12 miles south of Camp 9 and 130 miles from Broome. Thenceforth the ridges are practically continuous to Northern Territory, 400 miles to the east, to a similarly remote distance southeast, and to the south about 200 miles. "The worst class of country in Australia," said L. A. Wells;[13] and Warburton and Carnegie also have graphically described the terrors of the sand-ridge desert. The tractors, which had successfully negotiated the dunes at Bondi, N. S. W., in the trial tests, crossed these ridges with difficulty. In some cases it was necessary to turn completely about, change to reverse gear, and back over the ridges. Although the first ridges were only a few feet high and 100 to 300 feet wide, they became more formidable as we proceeded south, sometimes attaining a height of 60 feet and a width of 1000 feet and consisting of a complex of bare sand dunes largely devoid of vegetation but dotted with spinifex and some bushes. The ridges, at first approximately a mile and a half apart, become closer together toward the south until they average as many as four to the mile.

The sand ridges maintain a striking regularity of direction, 15° north of east to 15° south of east, the trend being influenced by the prevailing winds from the southeast.[14] Rarely do they converge and unite; and for the most part they maintain their identity and fail to disappear either east or west, continuing in fairly straight lines into the remote distance. Later observations on the coast between Anna Plains and Pardoo Station showed that even there the ridges change little in type from point to point.

The sand hills constitute the most recent feature in Western Australia and are still in process of formation not only on the coast but also over large areas in the interior. Our main traverse south from the north plateau escarpment crossed 85 sand ridges. An automobile, once arrived between any two ridges, could travel for long distances between them, jolting over the spinifex clumps which are rarely absent

[13] *Op. cit.*, p. 157.

[14] This is well shown on Warburton's route map.

from any square rod of the surface. Little possibility exists of a car crossing the ridges without a special appliance for the wheels, which sink deep into the sand, but caterpillar tractors can cross them if well supplied with gasoline, water, and spare parts. Between the ridges the valleys are broad and slope centerwards, vegetation sometimes

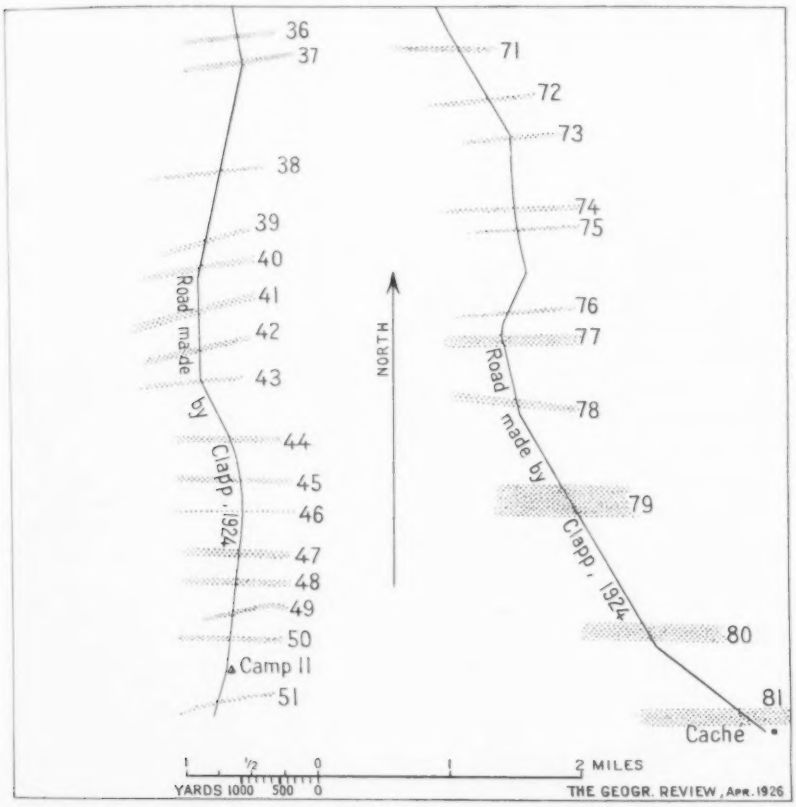


FIG. 13—Diagrammatic mapping of sand ridges, showing orientation and frequency. Clumps of spinifex are dotted all over the country, which otherwise is sand with some bushes.

suggesting that water may exist below the surface, although none was found by digging, and no distinctive shrub or tree known to be a sure guide to water was seen. Occasionally, even far to the south, considerable brush intervenes between the sand ridges, but the pindan lies far behind.

The sand ridges not only encumber the interior of the plateau, but they strike the coast throughout a belt roughly 70 miles wide between Wollal and Pardoo homesteads behind Ninety Mile Beach, and they render motor travel difficult along the main north-south road between Broome and Port Hedland.

The common designation "Great Plateau of Western Australia," as remarked above, seems to the writer too generalized and often loosely used. Of course, in ascending the north escarpment and traveling near its brink for scores of miles at 600 to 800 feet above sea level the plateau appears a unit. But, as was learned in traveling south from the escarpment, the plain slopes south from this elevation to an altitude of roughly 300 feet in the inter-ridge valleys near the fiftieth sand ridge, 40 miles or so south of the escarpment and 170 miles more or less southeast of Broome.

McLarty Hills and Joanna Spring

All maps of Western Australia bear the inscription "McLarty Hills" not far from the southeastern point reached by this expedition. No explorer's route is recorded as touching them, and the writer has learned nothing definite as to their character or identity. If they are similar to the "Radi Hills" mapped southeast of Wollal and some smaller prominences which have found their way to government maps, they need not be considered as more important than a host of others in the vast desert area—either minor remnants of a previously existing table-land standing above the regular plateau level or being simply among the more prominent of the sand hills. Mr. P. J. Tighe of Broome speaks of having visited these hills and states that they are "black conical hills" yet likens them to certain minor plateau remnants observed to be only a few rods in height and diameter, situated below the northern escarpment.[15]

On the other hand Joanna Spring, mapped 40 miles southeast of McLarty Hills, 185 miles in air line southeast of Broome, and probably 50 miles from any point reached by this expedition, has been visited by four exploring parties.

The Tractors and Their Troubles

As a warning to future explorers of the Australian desert it should be remarked that the success of this expedition in entering the sand-ridge area was not because of the tractors used but in spite of them. The proper method of desert travel for that region remains the camel, and with camels Joanna Spring might have been reached early in the season. In future some form of tractor may be devised to make the trip. It should be borne in mind, however, that most types of motor

[15] Quartzites and black hematitic quartzose phases of sandstone are only a vitrified phase of surface hardening due to peculiar climatic conditions and are common in rocks of all ages throughout Australia; hence one need not postulate a remote geologic age of the "hills" on the basis of their color alone. From the description it would seem that the McLarty Hills may be of no geographic or geologic importance and may possibly constitute lateritic (surface-vitrified) outliers of Permo-Carboniferous or later age similar to outcrops already seen in valleys between the sand ridges at Camp 12, 185 miles by tractor southeast of Broome, from which point nothing but a maze of high sand ridges was visible in all directions.

vehicle require more water than a camel and that the writer's expedition traversed the desert area at the close of its second year of drought in the longest dry period ever known in Western Australia when most water holes in the desert area were dried up and those on its edges were rapidly disappearing.

It was not only necessary for tractors to haul gasoline (on which an average of only five miles a gallon was attained) but also water, a gallon of which lasted about two and a half miles in the sand-hill country. A claim had been made that, since tractors have crossed the Sahara, they would have no difficulty in the Australian desert. But in Australia the sand hills are worse, the pindan that must be traversed to reach the desert is more dense and extensive than anything known in the Sahara, the population of the Westralian desert is less, and water holes are practically absent beyond the desert border so far as a sufficient supply for motors is concerned.

Automobiles could not make the trip except for the first 30 miles from Broome; though ultimately, after arduous road cutting by the scouting party, a car and a truck were driven over 100 miles out but at great physical discomfort to the drivers. Horses or camels are not available in Broome; hence the work of the supply party was done by tractor. Depots were established every 15 or 20 miles at which the motor tanks might later be filled on the outgoing and return trips. At most of these depots it was likewise necessary to deposit drums of water. After a point over 150 miles from Broome was reached, caches of food were stored in tins, buried so as to prevent theft by wandering aboriginals.

The drums were partially protected from the heat of the sun by boughs where available, but the evaporation loss was much greater than expected. The liquid forced its way through the tin owing to expansion caused by the intense heat, though such drums are not filled full. At night the temperature may drop as much as 70 degrees, and whatever dampness exists in the air is precipitated outside in the form of dew. Within a gasoline drum a vacuum is produced owing to contraction of air and liquid, in consequence of which a small amount of damp air is daily sucked into the drum. Thus is explained the occasional finding of water in a carburetor, causing repeated annoyance to drivers. On future motor expeditions under similar climatic conditions a means must be found to prevent this interchange of gasoline and air.

The machines themselves were far from perfect and caused serious delays. The last but not the least of the difficulties was that due to the rubber caterpillar bands, which proved unsatisfactory in use. This final blow ultimately caused abandonment of the tractors and substitution of automobiles for completion of the expedition. In Dodge cars a trip of several thousand miles was made in the country south of

Broome down the coast and into the interior of Pardoo, De Grey, Ashburton, Lyndon, Gascoyne, Murchison, and other districts of Northwest Division, before the return to Perth.

Southern Edge of the Desert

The southern margin of the Desert Basin is little known, although distant only a few miles from Yarrie, Warrawagine, Callawa, and other stations on De Grey and Oakover Rivers. These streams and the Fitzroy are among the few rivers in the Northwest that carry water during an ordinary dry season. The Oakover has running water for miles, being very different in aspect from any other stream between Broome and Gascoyne River, a distance of 650 miles. Between Oakover River and the desert stand several ranges of mountains, isolated mountains and hills which appear to be contemporaneous in age with the north plateau escarpment.[16] Like other parts of the Desert Basin and vicinity, this region has been little explored.

The Canning Stock Route enters the southern edge of the Desert Basin 300 miles from the coast, east of which Leo Jones believes the southeast angle of the basin to lie distant about 200 miles. Carnegie does not discuss the geology and evidently traveled south on the eastern flank of the basin but still in the desert. Gibb Maitland, the government geologist, states that the only evidence for the position of the east boundary of the Desert Basin in a geologic sense consists of "granite" reported by a policeman as seen not far from Northern Territory.

West of Oakover River and near the 121st meridian stands a persistent table-land which has been traced from near the junction of Oakover and Nullagine Rivers south to Braeside Station (an outstation of Warrawagine Station) whence it extends out of sight far to the south. Although only a few miles in breadth, it rises abruptly 100 to 120 feet from the valleys, is capped by quartzite, and lies nearly flat. On the writer's traverse south from near the junction of Oakover and Nullagine Rivers this table-land was paralleled almost continuously, and glimpses of it were also obtained northwards, where it enters Desert Basin and apparently merges with the Callawa Hills.

The Coast Bordering the Desert Region

The 300 miles of coast from Broome to Port Hedland is one of the most desolate in the world, traversed by a single road, over which only a few cars pass each year. In this stretch lie Edgar, Bohemia, Anna Plains, Wollal Downs, Pardoo, De Grey, and a few lesser stations, all

[16] The upper part of the Paterson Range is composed of Permo-Carboniferous strata, but ancient Nullagine (Cambrian) and (or) granitic rocks—sometimes veined with quartz—are known in the intermontane areas.

FIG. 14

FIG. 15

FIG. 14—Blacks pumping a well in the coastal section bordering the desert region.
FIG. 15—An aboriginal hut in the sand-ridge country.

located on the coast or within five miles of it. South of Hamiltons well the farthest outposts at which wells have been drilled or cattle maintained are about ten miles from the coast, beyond which the country is practically unknown. The only post and telegraph offices are Lagrange Bay and Condon, at which incoming and outgoing mails are rare. These places have, however, the benefit of a weekly airplane service which will stop anywhere on payment of the tariff, and the stations are provided with landing fields. Most stations maintain anywhere from a dozen to 50 dug wells from 30 to 100 feet deep, at which a plentiful supply of water is generally obtained, although sometimes it is slightly saline. All stations visited by the author are shown on the map, Plate II.

The outstanding physical feature of this coast is Ninety Mile Beach, which stretches south from Lagrange Bay to a point on Pardoo Station—a perfect beach backed by sand dunes. There is only one road behind it, houses average only one in 30 miles, and at the time of my visit not a white woman lived between Edgar and Pardoo Stations, a distance of over 200 miles.

In places between Lagrange and Port Hedland are raised sea beaches of sandstone, limestone, or comminuted masses of shell and sand grains, from 2 to 50 feet above tide level. In topography they take the form of beachlike belts sometimes paralleling the coast for many miles. If the dead trees surrounding the sea-level plains north of Broome indicate a present sinking of that part of the coast, the raised beaches indicate recent rising in the area from Lagrange south. The pivot in change of level appears to be not far from Broome.

As a rule this coast is low, but promontories at Capes Villaret and Bossut between Broome and Lagrange and at Gantheaume Point, just north of Broome, are 60-foot bluffs of white Jurassic sandstone. Near the coast are various belts of sand dunes, including consolidated dunes belonging to an earlier Recent epoch, some of which have been cut into by the sea, forming vertical cliffs 20 to 50 feet high. In the vicinity of Wollal and Pardoo the desert sand ridges, extending east and west, reach the coast and connect with the coastal dunes; hence traveling between Wollal and Pardoo is more difficult than in any coast section between Beagle Bay and Onslow.

Perhaps of the same age as Capes Bossut and Villaret is Mt. Phire, situated due east from Anna Plains homestead and 16 miles from the coast. This eminence is a table-land two miles long in a northeast-southwest direction, standing 100 to 125 feet above the ordinary spinifex-covered sandy plain. From Mt. Phire a tower-like peak of similar altitude was observed about 40 miles northeast and estimated 30 miles back of Cape Bossut. Callawa Hills, 20 to 30 miles north of the confluence of the Nullagine and Oakover Rivers referred to above, are extensive mesa-like prominences which may represent

a similar ancient peneplain surface. The two plateaus—the widespread one constituting the desert area and composed of Permo-Carboniferous strata beveled by probable Tertiary peneplanation and a more fragmentary one consisting of Jurassic beds—should be carefully differentiated in any consideration of the physiography.

Aboriginals of the Northwest

From the time of leaving Hamiltons well, 42 miles from Broome, "smokes" were occasionally seen to the south and east. These smokes are made by blacks at camp fires, in signaling to their friends, and in burning brush and grass during their hunting expeditions—large areas being burned to drive out the lizards (goannas) and snakes which constitute their chief food. Difficulty, however, was experienced in getting into touch with the natives when a guide was required.

The question will naturally be asked: "How dangerous are the blacks?" The answer from any person familiar with them and their life and customs varies little, i. e. that they are dangerous and treacherous. The native habitat of the blacks is the wild interior, and it is their custom and life to kill both men and animals. It seems probable that they can no more resist killing a white man, given an opportunity, than many a civilized man can resist shooting deer in or out of the lawful season.

In the grasslands near the border of the desert and especially in Northern Territory, where the grass sometimes grows many feet tall, the blacks can easily hide and approach very near to a party of whites without being seen. They are adept in dragging spears between their legs as they walk, and an innocent white traveler may suppose them entirely unarmed. On approaching within a few yards, however, a sudden twisting of limbs occurs, the spear rises to the hand and is hurled with intense force at the unsuspecting white victim who is advancing (as he supposes) to a peaceful parley. The blacks, however, will seldom attack a white man during daylight hours. At night and especially at dusk the blacks will stealthily creep up to a camp and be ready to attack with the first rays of morning light.

How many aboriginals live in the desert? The writer has asked this question many times and has failed to receive consistent replies. The blacks cannot be numerous, for the official estimate gives only about 26,000 for the entire state. The opinion of the writer is that in the Desert Basin there may not be over a thousand or two. They seldom travel in large bands, being divided into too many tribes and maintaining too many feuds among themselves to gather in force anywhere. If the number of smokes seen to ascend in the distance can be used as an index, not more than three parties of blacks are often within range of smoke visibility, which may be considered a radius of

not over 50 miles. The desert comprises a score of such areas; thus, if the hypothetical three parties average ten persons each (a fair estimate), the blacks within range of visibility would number not over 30, and those in the entire desert would number only 600. Assuming that some aboriginals are always on the march or otherwise occupied than in building fires, the rough estimate may be brought to one or two thousand. No more reliable estimates are known to have been made.

Most blacks seen outside of the stations were poor specimens, tall but thin and emaciated and wearing little or no clothing. They are dark chocolate-colored, in contrast to the much lighter half-castes who frequent the coastal regions. They have a low forehead, a flat nose, large teeth, and thick black hair. They are generally unwilling or unable to work, although the white inhabitants declare that a black man can act as a cowboy under supervision. Many blacks are actually employed on the stations, each of which is managed by one or several whites assisted by a considerable number of blacks.

Future of the Region

In conclusion it should be emphasized that the country described in detail lies on the margin of the Westralian "desert" and must not be considered typical of the desert as a whole. In fact, the route traveled from Broome to a point roughly 100 miles southeast of that place is quite different from desert country as commonly understood, and much of it would doubtless be good pasture land in seasons of ordinary rainfall. One difficulty in determining actual conditions on the basis of experience is that the party entered the region, as has been said, at the close of two years of intense drought.

The coastal region is habitable pastoral country. In this belt all that is necessary to assure proper stocking and farming is to find the management and the labor. Inland are areas where plenty of grass has actually been seen 100 to 150 miles from the coast. Judging by the Government's achievement on the Canning Stock Route, a limited number of wells can be sunk in the inter-sand ridge areas that will serve as centers of future successful cattle stations in other portions of the desert and semidesert.

According to the Westralian land law an area of 10,000 acres can be acquired by one individual; but beyond this specified area he can lease as much as 1,000,000 acres for grazing purposes on annual payment of ten shillings ($2.50) per 10,000 acres. Western Australia has 245 ranches of over 100,000 acres each, and some stations of over 1,000,000 acres exist owing to an amalgamation of interests. Most of the original leases expire in 1932; but some of them run until 1948, and they will presumably be renewed from time to time as may be required, until influx of greater population necessitates cutting down

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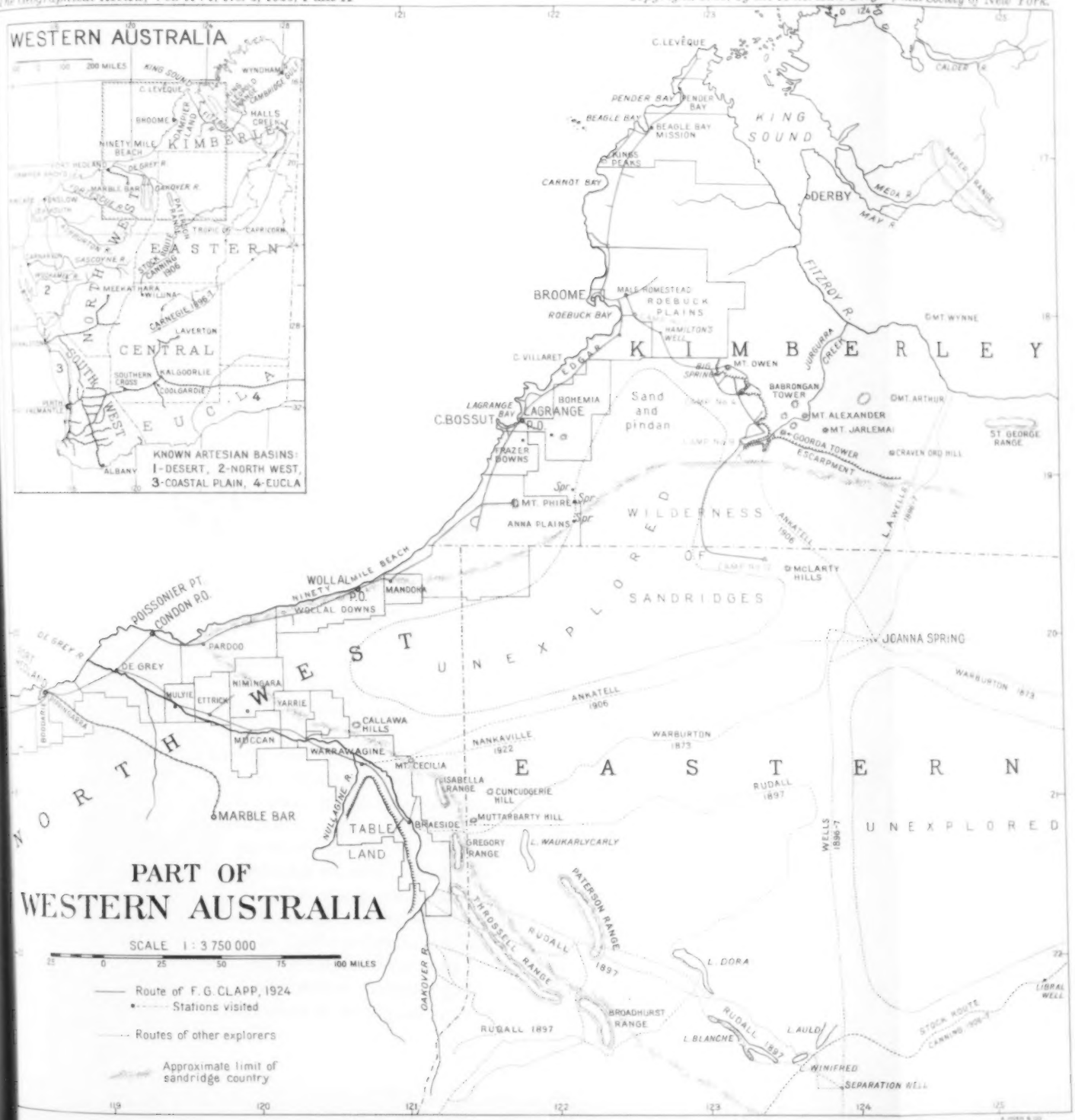

their size. On some of the large stations the feed is so poor that 10 to 50 acres are required for each sheep.

Further inland the climate is drier. In the previously unexplored area back of Anna Plains the sand ridges are for the most part bare, topped only by a few shrubs and low trees. They become increasingly worse inland, constantly shifting and carrying little or no vegetation. Certainly no water or animal life was seen by the writer throughout 70 miles of the unexplored area.

Strange to say, the area between the Ninety Mile Beach and Joanna Spring, bounded on the northeast by the great escarpment, on the southwest by the rabbit-proof fence, and on the southeast by Warburton's route, is as large as any entirely unexplored area in Western Australia. It amounts to about 25,000 square miles—about the size of another unexplored area situated between Carnegie's northward and southward routes, bounded by Warburton's route on the north and Giles's route on the south.

The ideal route to be selected for penetrating the central regions would probably be directly east from Anna Plains Station to the reported springs 45 miles distant, thence east between parallel sand ridges to the eastern portions of the desert. The writer is confident that this route could be traversed by persons already experienced in the region by using an automobile (not a truck) provided with extra wide wheels or tires.

Before an opinion can be expressed on the much mooted question whether any portion of Australia actually constitutes a desert, a definition will be necessary. A desert is generally conceded to be an uninhabited, uncultivated, barren, waterless, and treeless region; and parts of the Westralian desert certainly fulfill this description. Other deserts of the world in comparison are found to be, many of them, even more settled and less barren. Hence the term "desert" seems applicable.

However, admitting that parts of the Westralian desert have pastoral possibilities, the population that can be economically supported by the labor of raising cattle therein is not likely to exceed a score of whites for each million acres. This is at the rate of a thousand or two persons for the entire desert, or a similar estimate to that already given for the probable number of aboriginals at present living there. Actually many more people could live in the region if provided with food from the outside; yet no white person *will* live in the Northwest of Australia unless forced to do so in order to earn a living. Since time has shown that one white man and a few blacks can handle a cattle station of several hundred thousand acres, the pastoral possibilities offer little inducement to immigration so far as this particular region is concerned.

THE DELTA AND ESTUARY OF THE COLORADO RIVER

Godfrey Sykes

Desert Botanical Laboratory, Tucson, Ariz.

[With separate map, Pl. III, facing p. 254]

IT can be truthfully said of the Colorado that it is the most seen but least known of all of the great Western rivers. Many thousands of tourists and sight-seers visit the Grand Canyon each year; four transcontinental railroads and several national highways cross the river at various points; yet hundreds of miles of its course only rarely come under observation, and not a single center of human activity of major importance as yet exists upon its banks. The river is undoubtedly the greatest undeveloped asset of the Southwest, one of the most valuable of the entire West, and ranks very high amongst the potential natural resources of the nation. Its future value lies principally in two directions: for the further development of irrigation, and as a source of power. An ambitious plan, however, for the diversion of a part of its water for supplementing the municipal supply of Los Angeles is also being discussed and is amongst the possibilities.

The mere magnitude of the river system is impressive. The main channel has a total length of 1750 miles, the drainage area comprises some 240,000 square miles in the United States and over 2000 in Mexico, the mean annual discharge is about 16,500,000 acre feet, and the flow varies from about 1500 to more than 200,000 cubic feet of water per second.

At least seventy per cent of this water comes together at the junction of Grand River (now called the Upper Colorado) with the Green River, at an elevation of 3800 feet above sea level and some thousand miles from tidewater. Herein lies the possibility of power development, for from this main gathering point downstream to the vicinity of the Bull's Head Rock, at an elevation of only 500 feet at the upper end of the Mohave canyon, nothing in the way of irrigation by gravity flow will ever be possible, as the whole intervening course of the river is through the succession of great canyons which have brought the name of the Colorado into prominence.

Tentative schemes have been worked out at different times for a series of dams in this canyon section which would utilize practically the whole 3300 feet of fall; and some such plans will undoubtedly

materialize whenever a profitable market develops for the enormous power which here lies latent.[1]

From the head of the Mohave canyon to the mouth of the river, irrigation will always be of paramount importance, as will also be the case in the upper basin, above the Grand and Green junction, although perhaps not quite so markedly, since it is in the sun-warmed soil of the valleys and mesas of the extreme southerly portion of the arid region that the results are most profitable. Several projects, of moderate size and importance, are already in operation between the Mohave canyon and the mouth of the Gila, but any material extension of the existing systems will involve a comprehensive scheme for flood control and water storage for the entire river.

A few miles above the mouth of the Gila and the head of the Colorado delta the Reclamation Service constructed some years ago, as one of its earlier major projects, the Laguna diversion dam. The dam itself was completed in 1909, thus definitely closing the river and establishing its status as a non-navigable stream.

The fact that for a number of years past the Colorado River, in its own name and channel, has not reached tidewater has escaped general attention, although the physiographic changes now taking place in the delta region are a matter of unusual geographical interest. It is with these changes that the present paper is concerned.

The Delta-Building Forces

The delta proper of the Colorado lies principally in Mexico, although the floor of the Imperial Valley in southeastern California is in reality a part of the deltaic fan, and constant engineering vigilance is necessary in order to insure this important region against further invasion by the river.

A small complex of hills some eight miles west of Yuma, culminating in a ridge locally known as Pilot Knob, is the last outlier of solid ground bordering the river or any of its distributaries until the flank of the delta touches the toe of the Cocopah Mountains, fifty miles to the southwest. Directly southward the stretch of alluvium and river outwash is much greater, for the first conjunction of solid rock and water in that direction is at San Felipe Point, some forty miles down the western shore of the Gulf of California and at least a hundred miles in an air line from Pilot Knob.

It is necessary to keep these directions and relative distances in mind in order to get a clear conception of the interplay and magnitude of the forces which have been instrumental in bringing about the present phase of delta building.

[1] The recent investigations of the U. S. Geological Survey are given in the report by E. C. LaRue: Water Power and Flood Control of Colorado River Below Green River, Utah, *U. S. Geol. Survey Water-Supply Paper 556*, Washington, 1925.

The Cocopah massif, in its probable former state of an island or at least a peninsula attached by a northwestern prolongation to the farther shore of the gulf, has in effect formed an obstruction to the free discharge of the sedimentary matter from the river and has been instrumental in diverting a great fan of alluvium towards the northwest. Strong tidal action across the ever shoaling tip of the growing delta must have played an important part in spreading the load in this direction and also in filling the depression behind the Cocopah barrier as the nearer basin was gradually shut off from the sea.

The tides in the Gulf of California are of the type usually found in funnel-shaped gulfs and increase in range as the head is approached. At Cape San Lucas the extreme movement is about seven feet; at the mouth of the Colorado this has increased to over forty feet, or a ratio of about six to one; and this of course implies strong tidal currents and great scouring and transporting power. This is the agency that has already carried and is still extending the alluvial tongue along the shore in a southerly direction, masking the former coast line with a fringe of sedimentary matter.

There is evidence too, at many points in the delta region, that material changes of level have taken place in very recent geological times; and these have doubtless played their part in modifying local conditions.

Most important of all is the enormous quantity of solid matter carried in suspension by the Colorado and its tributary streams and finally deposited in the delta or brought under the influence of tidal action. The load varies greatly by season and by year, but the annual mean volume has been estimated, probably with reasonable accuracy, as being equivalent to a mass of dry soil a square mile in area and from 125 to 175 feet deep, or in other words to a deposition one foot in depth over an area of from 80,000 to 110,000 acres.

The writer was familiar with the delta and estuary of the river more than thirty years ago; he visited it thereafter at intervals for a further period of ten years and has had some recent opportunities to examine it again, thus gaining a perspective of the energy and magnitude of the forces involved in its rapid mutations.

Delta building is an intermittent process. When river flow is subject to great seasonal fluctuation in volume and especially, as is the case with the Colorado, when the period of maximum flow and consequent inundation of low-lying land corresponds with the season of greatest activity in the growth of vegetation, diversion of the main channel may be delayed for many years through the reinforcement and upbuilding of the riparian strips by plant growth. In such cases long periods of comparative quiescence with alternative periods of greater activity, when the balance is upset or the inertia of the screen of vegetation is overcome through exceptional floods or extra-

FIG. 1

FIG. 2

FIG. 3

FIGS. 1, 2, 3—The three corner stones of the delta. Figure 1, Pilot Knob; Figure 2, Cerro Prieto, an outlier of the Cocopahs; Figure 3, San Felipe Point.

neous causes, may be expected. Such a period of vigorous change began in the Colorado delta some twenty-five years ago and is still going on.

The previous sixty, or perhaps seventy, years had seen comparatively little change in the alignment of the main channel, although symptoms were to be found even thirty years ago indicating that great changes were impending.

Changes in the Last Century

In order to make the tale plainer, all available maps and other data bearing upon the course of the lower river and the configuration of the shores of the estuary for the past hundred years have been gathered together and are here reproduced or otherwise noted. The material is scanty at the best; but it has not been thought necessary to supplement it by any reference to the earlier and fragmentary accounts from Spanish sources, since these can seldom be relied upon where precise geographical information is desired.

The earliest examination of the mouth of the river that was made under conditions approaching modern accuracy was that of Lieutenant R. W. H. Hardy of the British Navy in the year 1827. He sailed to the head of the gulf and entered the mouth of the river in a small schooner named the *Bruja*, spending several weeks in the estuary.[2] He states specifically that no charts or sailing directions for the head of the gulf were known to him. His map of the gulf and chart of the estuary contain practically all the information he gathered with the exception of a series of log entries, which he mentions as being contained in an appendix but which his publisher has seen fit to omit from the volume.

Hardy's chart is of especial interest as indicating the general shape of the estuary and the position of the larger shoals at that time. Two points are worthy of note: first, that the westerly channel into the head of the estuary was then carrying the main flow of the river; and second, that the pronounced deep bend in the channel, below the junction of the two branches, was then in existence. The western fork was supposed by him to be the Colorado and the eastern one the Gila; and there is little doubt that this error of Hardy's concerning the point of confluence of the two streams was taken into consideration some twenty-five years later when negotiations were under way with Mexico preparatory to the Gadsden Purchase. By locating the western termination of the new boundary line at a point "twenty miles south of the junction of the Gila and Colorado Rivers" it was at least hoped that an outlet to tidewater might be given to the newly acquired territory.

[2] R. W. H. Hardy: Travels in the Interior of Mexico, in 1825, 1826, 1827, and 1828, London, 1829.

FIG. 4

FIG. 5

FIG. 4—Grand Falls, Little Colorado. The "South Fall" showing the color and "texture" of the water. Spring of 1915.

FIG. 5—The Rockwood Gate, the heading for the Imperial Canal. Colorado River at left, Canal at right, corner of Pilot Knob at extreme right.

When the estuary again came under observation in the early fifties, Hardy's report received a good deal of adverse criticism, for it was then found that the easterly branch was the main river and that the one which he had entered and ascended was little more than a backwater. It was probably in a spirit of derision that the name of "Hardy's Colorado" was given to it; and, although at the present time

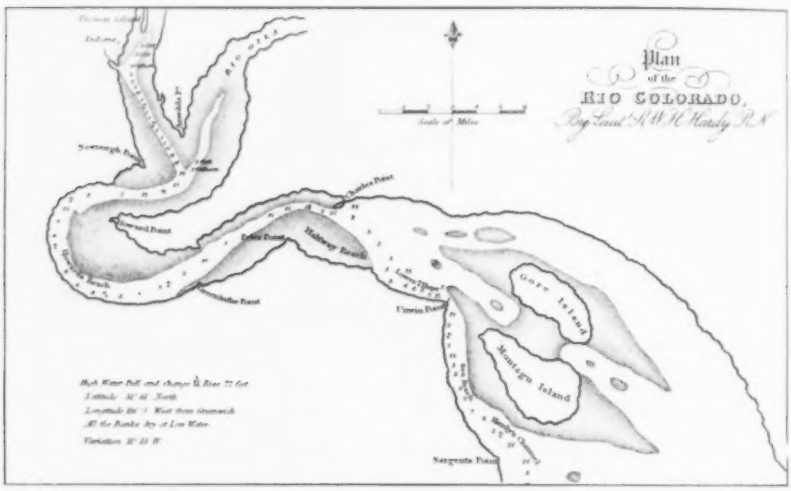

FIG. 6—Reproduction on reduced scale of Hardy's chart of the Colorado estuary.

it again carries the entire volume of Colorado water into tidewater, the name still persists.

Hardy had been handicapped in his work by the lack of instruments, for he confesses that he had neither chronometer nor sextant; and so his shore positions were doubtless determined by compass bearings and dead reckoning, and his latitude was checked by some method of estimating either an azimuth and true altitude of Polaris or the meridian altitude of the sun. Under the circumstances it is remarkable that his positions were so nearly correct, and it is reasonably certain that his detailed observations of the shore line and channels are substantially accurate. It is worthy of note that at the present time, with the discharge of the river once more taking place through the Hardy channel, the deep sweep of the bend below the junction is again a feature of the estuary.

The next trained observer to visit the mouth of the river was Brevet Lieutenant G. H. Derby of the Topographical Corps, U. S. Army, who was sent there in the winter of 1850–1851.[3] Derby was well equipped with chronometers and sextants to make an accurate survey and seems to have done so as far as his work extended. He checked Hardy's

[3] *32nd Congr., 1st Sess., Senate Exec. Doc. No. 81.*

work and found it very inaccurate in many important particulars, although he mentions in his report that profitable use was made of Hardy's book.

Apart from a general error in all Hardy's positions, the two surveys were in substantial agreement until Greenhithe Point was reached; but from there onwards to the mouth of Hardy's Colorado a great

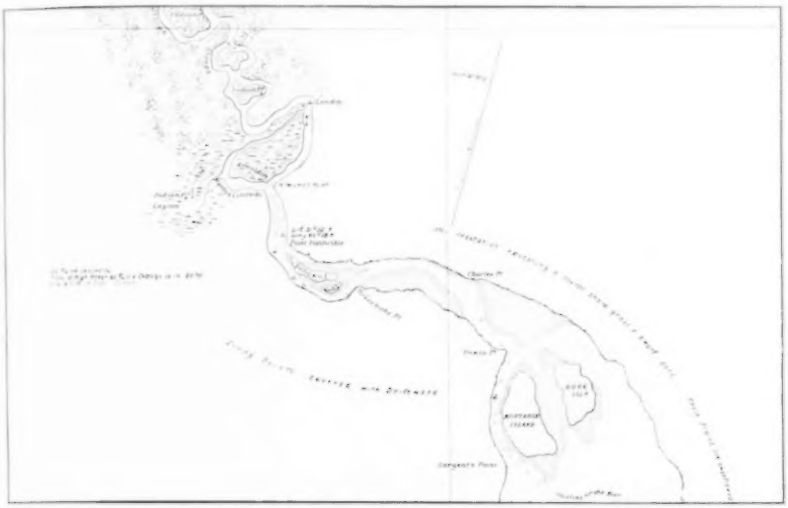

FIG. 7—Reproduction on reduced scale of a part of Derby's chart of the estuary.

change had taken place in the intervening twenty-three years. The long, narrow peninsula terminating in Howard Point had disappeared, although the Pelican and Gull Islands of Derby's map probably represented fragments of it. The deep sweep of Howards Reach had straightened out; and Arnold's Point, at the confluence of the two rivers, had become blunted off to an obtuse angle. All these and other changes have recurred in this portion of the estuary more than once since, and the present configuration corresponds rather more closely to Hardy's delineation than to that of Derby.

After examining and mapping the estuary Derby began to work his way up the eastern channel, having learned from some boatmen who were then established on the lower river, probably with a small light-draft steamer, that this was the route used in the passage to Yuma. At the head of tidewater he met Major Heintzelmann, the commanding officer at Fort Yuma, on his way down from the post. The Major and his party had mapped the river on their way down to the point at which the meeting took place, so that Derby did not go upstream any farther but combined the two reconnaissance surveys of the channel in his final report and map.

Lieutenant J. C. Ives was the next official hydrographer to appear on the scene. He was sent to the head of the gulf in 1857 with a small steamer, the *Explorer*, built in sections and rather heavily engined. This boat was assembled on a mud flat near Unwins Point and after various vicissitudes, fully and graphically detailed in Ives's report, was at length successfully worked upstream to a point in the Black Canyon.[4]

The beautifully executed map accompanying the Ives report is attributed to F. W. von Egloffstein, the topographer of the expedition, and has had a long and wonderful career. It was quickly adopted in all official quarters as the standard conventionalized delineation of the Colorado and remained so until quite recently in charts published by the Hydrographic Office and in kindred Departmental publications. This is the more remarkable because its evanescent character is so plainly shown by the intricate network of channels that traverse the delta. Considering the time of year (midwinter) at which the Ives survey was made the network of channels is doubly striking, although they may have been brought into temporary existence by means of a flash flood from the Gila or elsewhere.

Steamboat traffic was established on the river in the early fifties, first to Fort Yuma but later on to other points farther north. The steamboat men had the river practically to themselves for about twenty-five years, beginning in the early fifties and ending with construction of the Southern Pacific Railroad as far east as Yuma in 1877; but during that time they recorded no major changes in alignment. The usual seasonal shiftings of sand bars and shoals, with the deepening or straightening of bends and cut-offs, were encountered, and there is a record of at least one downstream voyage of a steamer having been made through some series of westerly channels which ultimately brought her out into the Hardy; but this was accomplished in a season of exceptionally high water and probably indicates a willingness to explore and take chances on the part of her captain rather than evidence of orthodox navigational possibilities.

Commander, afterwards Admiral, Dewey made a survey of the Gulf of California with the U. S. S. *Narragansett* in 1873–1875 and visited the mouth of the Colorado upon several occasions. His work, however, did not extend beyond the limits of deep-water navigation or into the internal territorial waters of Mexico; and so nothing was added to the previous knowledge of the river channel above the estuary, and the Ives-Egloffstein map was again used and fitted onto the newly surveyed work.

A meander survey of the river channel between Yuma and the sea was made by the writer in 1891 and was supplemented by further examinations in 1892 and 1893. This was a period of great interest,

[4] J. C. Ives: Report Upon the Colorado River of the West, War Department, Washington, 1861.

FIG. 8—Reproduction on reduced scale of a part of Ives' map of the Colorado.

for the river was then beginning to show definite signs of a vigorous swing westward. Notes were taken at various times of large quantities of water passing over the western bank and through accumulations of drift into more or less definite channels in that direction. A series of years followed, however, with only moderate summer floods, and no further break from the existing meander belt had taken place when the region was once more visited in 1898.

In the meanwhile the full burden of silt had been carried into the estuary through the definite stabilized channel, and the impression was received at that time that the tidal flats below the mouth of the Hardy were choked and overburdened with sedimentary matter. Tidal scour seemed for the time being unable to cope with the load, and the tortuous passages between the mud flats made navigation of the estuary rather a difficult art.

Changes in the tidal channels and safe anchorages in the estuary during the era of navigation were of course of vital importance to shipmasters, and a partial record of those that took place before 1875 has been obtained by the writer.[5]

From 1850 to 1860 the navigable entrance to the river remained to the westward of Montague Island, as in the time of Hardy and Derby. From 1860 to 1863 the eastern channel was generally used, but in 1863 it had definitely changed once more to the channel lying to the westward of Montague Island, changing back again to the eastern channel a few years later. At one time it was possible to enter the river through the opening between Gore and Montague Islands, passing from there to the Sonoran shore and following it up to the anchorage. Islands appeared and disappeared. Such was the case of Hilda Island[6] formed about 1891 and reduced to a shoal some twelve years later. The extent of changes on the former coast line towards San Felipe Point during the past fifty or sity years may be shown by the example of Ometepec Bay (Fig. 12).

In the earlier editions of the West Coast Pilot, U. S. Hydrographic Office Publication No. 84, the following description is given of Ometepes (or Ometepec) Bay: "Ometepes Bay (named by an exploring party on the steamer Ometepes), situated about 20 miles southward of Robinsons' Landing, Colorado river, in latitude 31° 30′ N., longitude 114° 52′ W., has an entrance 300 feet wide and ¼ mile in length, with a depth of 3 fathoms of water at half tide. The bay, circular in form, is about 3 miles wide, and free from hidden dangers. It is perfectly landlocked, and has a depth of 5 fathoms of water. The rise and fall of the tide is said to be 25 feet. The bay abounds in turtle, fish, and game."

[5] Notes taken of a conversation with the late Captain J. A. Mellon in 1919.

[6] See the author's map accompanying the article "The Delta of the Rio Colorado," by D. T. MacDougal, *Bull. Amer. Geogr. Soc.*, Vol. 38, 1906, pp. 1–16.

According to men acquainted with the mouth of the Colorado during the steamboat era the entrance to this bay was rapidly shoaling, even before 1880. Several attempts to relocate it were made between 1891 and 1898 but without success. Any precise location of the actual shore line in this region is beset with many difficulties. The tides are large, and the slope of the shore is so gradual that an intertidal belt as much as five miles in width is uncovered and recovered daily, with nearly twice the distance subject to inundation at the time of exceptional spring tides; and the mud which composes the shore is so nearly fluid as to make a landing at most points a matter of extreme difficulty. The examination was carried sufficiently far, however, as to warrant the opinion that no such opening existed in the coast line as had been found by the *Ometepes* explorers. A recent examination of the coastal belt between the Colorado estuary

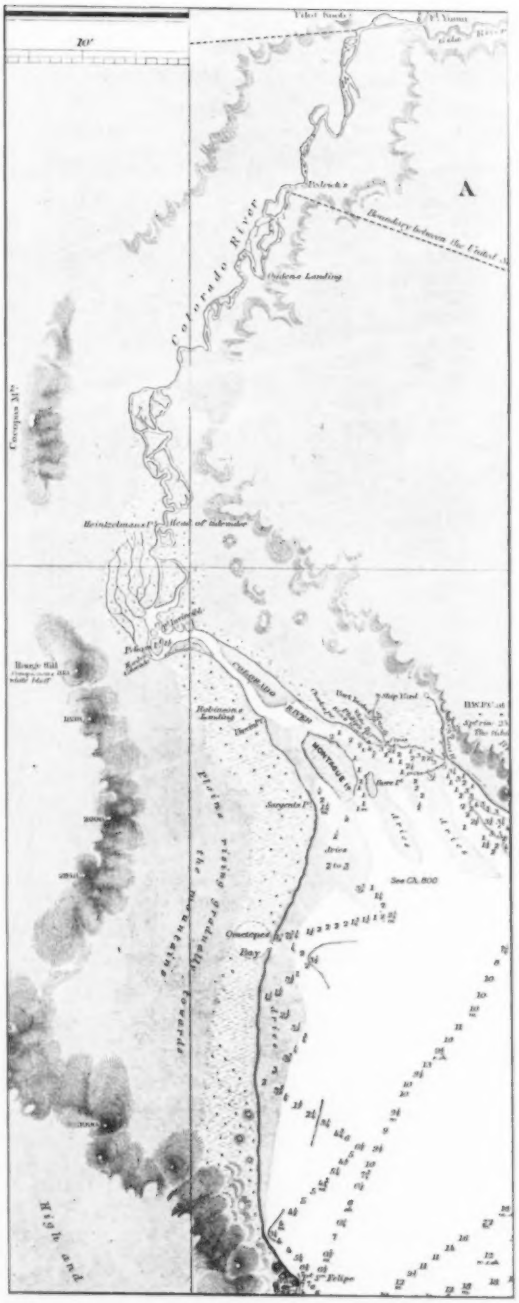

FIG. 9—Reproduction on reduced scale of a portion of Hydrographic Office Chart No. 619, 49th Edition, showing extensive corrections made in 1895.

and San Felipe Point, carried on from the land side, has at length made the whole matter plain. Ometepec at the present time is a *salada* and not a bay at all. Both the entrance channel and the circular bay itself have ceased to exist and are merely represented by a great T-shaped marshy region which may perhaps be still subject to considerable inundation at times of extremely high tides but which is in general little more than a broad, salt-encrusted area of dried mud

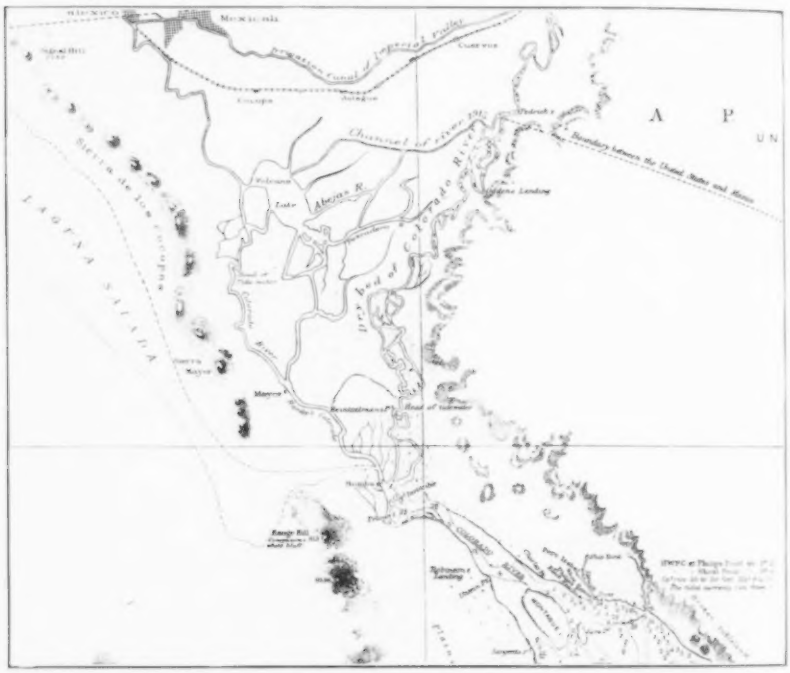

FIG. 10—Reproduction on reduced scale of a portion of Hydrographic Office Chart No. 619, Current Edition.

with shallow salty pools in the deeper depressions. Several concessions for exploiting these natural salt pans have even been granted by recent Mexican governing parties but so far without any practical development.

The recent examination of the coast towards San Felipe has also placed beyond doubt the advance of the littoral belt of mud for a distance of at least two miles since 1898, when the last detailed survey of the region was made.

Each successive swing of the river mouth to one side or the other of Montague or Gore Islands must have materially altered the configuration of the estuary by subjecting a different portion of it to direct tidal scour; and this influence probably extended about to the head of tidewater in both the Hardy and Colorado channels. Above this

point, however, there is little doubt that a general steady rise in level of the bed of the river took place during the long period of quiescence at least as far upstream as the head of the delta in the vicinity of Yuma.

Floods of the Colorado

Gauge readings, showing the height of the water at Yuma bridge, have been taken ever since 1878; but unfortunately these were not

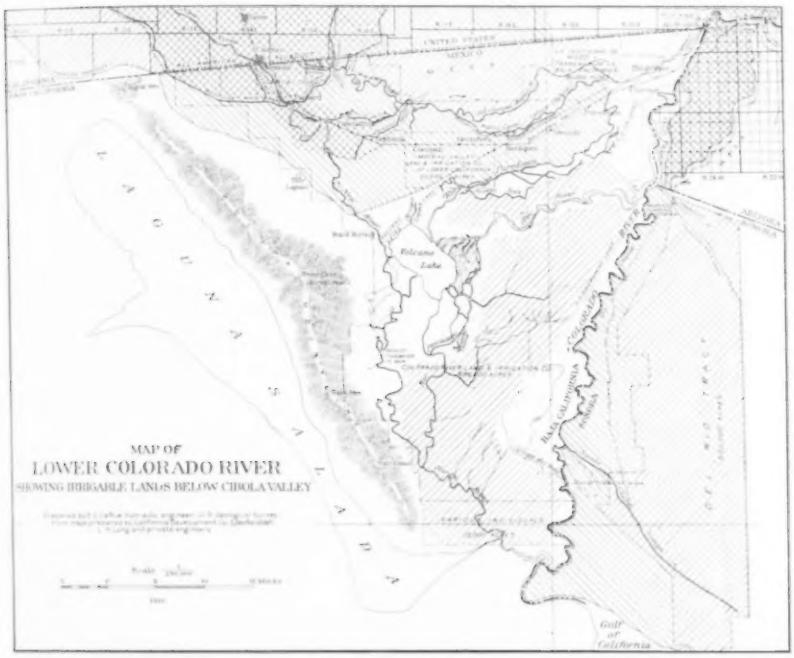

Fig. 11—Reproduction on reduced scale of part of a map accompanying E. C. LaRue's report, "Colorado River and Its Utilization," *U. S. Geol. Survey Water Supply Paper 395*, Washington, 1916.

supplemented by discharge measurements until 1902 and therefore were not of much value before the latter date except to indicate the times and relative magnitude of floods and other rapid changes in level. The instability of the river bed was hardly realized until these systematic discharge measurements were begun. It was generally assumed that successive readings of 25 feet at the gauging point meant a uniform volume of discharge at that height throughout the period of record and that when this volume was reached overflow began. There is little doubt, however, in the light of the later combined observations, that a 25-foot gauge reading in 1902 represented much less actual water passing the gauge than a similar reading did in 1878.

The year 1884 had been marked by a heavy summer flood, and the two following years by rather lighter ones; but there then followed

a long series in which the critical 25-foot mark was noticeably exceeded only once, and then by a short but destructive flash flood from the Gila in the beginning of 1891. The following ten years were characterized by entirely normal seasonal flow in the Colorado and the absence of any severe floods from the Gila. The existing channel alignment was maintained, though the menace to the western bank was ever growing with the raising of the river bed and yearly accretion to the flimsy riparian dam. After 1902 a series of years followed in which great and sustained floods occurred, and this period proved to be the actual factor that brought about the total diversion of the river from its former channel and course and gave rise to a state of general instability that has not yet come to an end.

The engineering operations initiated in 1901 for the purpose of developing the Imperial Valley were undoubtedly responsible for the great inflow of water to the Salton basin five years later[7] and have been the indirect cause of many of the later changes that have since taken place in stream alignment and local accumulations of silt, especially in the upper portion of the delta; but they have in effect been little more than an incident causing the partial retardation of the present general movement of the river towards the west. The operations caused a heavy flow of water to take place into the Alamo channel, allowing it to get beyond control therein, and so brought about the existence of the Salton Sea in the course of a few months. Water would have found its way there eventually, however, in large quantities through the slightly more circuitous route of the Paredones, Volcano Lake, and the associated network of sloughs and cut-offs which then formed connecting links between the Alamo, the Paredones, and the New River.

The series of years of abnormal floods lasted from 1903 until 1909, during which time the summer floods were very high, flash floods numerous and violent, and the winter level of the water at the gauging point much above the average.

Systematic observations of the upper portion of the delta were first undertaken about 1905, and these were gradually extended towards the south, as the danger point for the prosperous settlements in the Imperial Valley was found to exist at successive critical situations down the western slope.

The Flow to the Salton Sink

When the great flash flood in the early part of 1891 came out of the mouth of the Gila it raised the water level at the Yuma gauging point to 32 feet, or 7 feet above the point at which inundation of the Yuma

[7] See the author's map accompanying the article "The Desert Basins of the Colorado Delta," by D. T. MacDougal, *Bull. Amer. Geogr. Soc.*, Vol. 39, 1907, pp. 705–729, and also the summary account "A Decade of the Salton Sea" by D. T. MacDougal, *Geogr. Rev.*, Vol. 3, 1917, pp. 457–473.

lowlands began. The first outlet that proved to be adequate to relieve the main river channel in disposing of a discharge of this magnitude was the Alamo River. Before 1891 there had been no very definite entrance to this distributary, but an examination made a few weeks after the flood had subsided revealed a stretch of breached bank some half mile in length and numerous shallow channels which ultimately converged into the definite channel of the Alamo. This was noted at the time as a good illustration of the manner in which definite changes of alignment are likely to occur; but the flood, though violent, was of very short duration; and during the following and subsequent growing seasons the breach was again sealed by vegetation and floating drift. By tracing the course of the water towards the Salton Sink while some was still passing through the Alamo it was learned that the greater part of it went through Beltran's Slough and then into New River and the Sink. Beltran's Slough, which was then capable of carrying a heavy discharge, has since ceased to exist and is now buried under a sedimentary deposit several feet in thickness and many square miles in area.

In 1905, when the great invasion of the Salton area by the river took place, the Alamo had already been dredged and straightened, so that there was nothing to interfere with the free flow of water to the full capacity of the channel.

When the great opening in the bank was at length closed and the river once more brought under control, it was found that the temporarily disused channel of the Colorado had become obstructed to such an extent by the growth of vegetation and deposition of silt as to render advisable the construction of a line of levees down both sides, but especially the western side, of the imperiled section. These protective works might have been effective had they been more substantially built, but they proved quite inadequate to withstand the abnormal floods of the following three years and the very evident tendency of the river to escape towards the west.

The Paredones Channel

The Paredones, with its associated affluents, then became the most dangerous channel for a further possible invasion of the rich lands towards the northwest, as it was the nearest to the lip of the basin spoon. It had, however, no very well defined or permanent heading from the Colorado but began ordinarily as a series of confluent channels a short distance behind the riparian dam. It had originally served as a feeder for the shallow sheet of water known as Volcano Lake in times of high water in the Colorado. At such times most of the load of sediment was caught and deposited in the dense mat of vegetation along the river bank, and the water that finally found

its way into the channels beyond was comparatively clear. As soon, however, as the incapacity of the old channel of the Colorado to carry the full volume of the river forced a portion of the water to break a definite opening into the Paredones, the deposition of silt rapidly filled up the lake.

A ridge of slightly higher ground has existed to the southward of the Paredones plexus of channels, running roughly parallel to them and extending almost to the shore of Volcano Lake. It was highest at its northeastern end, falling with the general slope of the country towards the southwest. This ridge was taken advantage of by the engineers of the Imperial District as the next line of defense against the flood waters. A levee was built which ultimately extended from the protective works already existing down the western bank of the Colorado to the foot of the mesa forming the eastern rampart of the Cocopah Mountains. The Paredones was thus pocketed and eliminated as an immediate source of danger, and the river was once again confined to the old channel.

The Abejas Channel

The truce did not last long, however, for another weak spot existed a few miles farther downstream, almost opposite the termination of the international boundary line upon the east bank. This was the Rio Abejas, or Bee River, which had hitherto been an overflow drainage system, very similar to the Paredones, only in seasons of exceptionally high water receiving the direct flow of a portion of the silt-laden water through one or more temporary channels. It is almost certain that it was through this series of waterways that the steamer mentioned above once found its devious way from the main channel of the river into the Hardy.

A portion of the Abejas discharge had generally taken place directly into Volcano Lake during comparatively low water but, as the lake filled up with the annual flooding, more and more was obliged to seek an outlet towards the south and into the Pescadero.

Subsequent to the great incursion of water into the Salton basin in 1905–1906 much silt-laden water had found its way at each succeeding period of high water into the Volcano Lake region from the lower bends of the Alamo. This had tended to upset preëxisting levels still more, so that reversals in the direction of drainage became frequent and puzzling. Beltran's and Garza Sloughs disappeared, and for the time being it appeared that the rich Imperial Valley lands would be automatically protected from further flood danger. In the summer of 1908, however, the entire volume of the Colorado water finally turned into the Abejas and was carried once again directly towards Volcano Lake.

FIG. 12

FIG. 13

FIG. 14

FIG. 12—Looking eastward across the mud flats which now occupy the site of Ometepec Bay. (Photograph by Forrest Shreve.)

FIG. 13—The Diversion Cut. Looking upstream from the lower end.

FIG. 14—The Diversion Cut. Looking downstream over the new deltaic fan.

In the southwestern portion of the delta tenacious argillaceous soils and silts predominate in contradistinction to the sandy loams and other friable matter of the eastern side. Their presence has caused the Hardy, the Pescadero, and their associated waterways to assume a wholly different character from that of the other distributaries throughout the delta. The banks are in general steep, hard, and not easily eroded, and the channels themselves are tortuous and narrow. When high water occurs in this region the result is a general flooding until it can be gradually evacuated through the restricted openings to tidewater.

The Abejas channel rapidly widened and proved itself fully capable of carrying the entire normal flow of the Colorado down to the vicinity of Volcano Lake. Here a check occurred. The Pescadero refused to enlarge materially or to straighten; and the clay soil, covered with a dense mat of vegetation, resisted any general recessive cutting from points on the Hardy. Volcano Lake, on the other hand, had almost disappeared, and its various exit channels were closed. The way to the northwest was partly obstructed by the levees of the irrigation district, and the near-by slopes of the Cocopah range prevented any farther advance towards the west. The result was a general flooding of the region and the almost total deposition of the load of silt.

As the line of levees formed the sole barrier to the escape of flood waters towards the north and northwest where the valuable irrigated regions lay, constant vigilance was necessary to keep this line of defense intact and in advance of the level of the water and silt, which in each succeeding season of flood rose a foot or two higher against its southern face. At the present time the difference in level upon the two sides of the levee is as much as twelve feet at some points. Other tactics were perforce adopted. It was decided to tap the southern bank of the Abejas at some suitable point between its inception at the old river channel and this dangerous cul-de-sac and divert the whole flow directly towards the south.

The Diversion Cut

This plan was put into operation in the beginning of 1922 and, despite fears that have been entertained in some professional quarters, has hitherto proved to be very successful. The new channel was cut for a distance of about four miles towards the south and was directed towards the Pescadero, as grades and other factors seemed to presage a better chance of success by cutting in this direction than by attempting to redivert the flow into the old channel of the Colorado. An able and lucid account of the carrying out of this important work together with a discussion of the principles involved in its planning was presented to the American Society of Civil Engineers by Mr. S. L.

Rothery and covers all the engineering aspects of the actual diversion and subsequent behavior of the river in adopting the new channel.[8]

Secondary Delta Building

One of the most striking developments of the diversion has been the magnitude of the secondary delta building that has taken place about the mouth of the new channel. A pad of alluvium of considerable but as yet undetermined area has been laid down which has in places reached a thickness of from twelve to fifteen feet. The discharge from the diversion cut now spreads out through an intricate network of distributary channels over this new topographical feature, constantly adding to it, but up to the present time without cutting a definite outlet into the Pescadero. A hiatus of some three or four miles still exists.

The estimation of the load of silt carried by the Colorado has been based upon the turbidity of the water and has had no reference to the additional matter of larger size constantly rolled and carried by friction along the bottom. The amount of such matter in the case of flow taking place through a newly established channel such as the diversion cut is relatively very great; although, on the other hand, any obstruction to bottom flow or lessening of the gradient of fall of the stream bed brings about a prompt cessation of motion. It has been this added load that has so rapidly built the interesting secondary delta and thereby further impeded recessive cutting through the previously existing barrier of dense vegetation rooted in tenacious clay soil in the vicinity of the Pescadero.

The peak discharge of the Colorado has been far below normal for the past two years, and the trapping of sediment has been almost complete even throughout the high water seasons; but upon at least two occasions small boats have been successfully taken through the network of devious channels meandering across this rapidly changing region and have ultimately reached the Pescadero and Hardy.

A recent examination of the old channel of the river between the Abejas diversion point and the head of tidewater has disclosed the fact that a certain amount of comparatively clear water approaches it from the westward at the high-water stage, although there appears as yet to be no actual flow or infiltration into the channel itself; and a consideration of the grades and direction of drainage throughout the region points to the conclusion that when a great flood again invades the delta and further readjustments of channels take place and if—as seems to be entirely probable at the present time—the new diversion cut continues to deliver the main portion of the flow onto the growing

[8] S. L. Rothery: A River Diversion on the Delta of the Colorado in Relation to Imperial Valley, California, With Discussion, *Trans. Amer. Soc. of Civil Engineers*, Vol. 86, 1923, pp. 1412–1447.

alluvial fan, the discharge to the estuary will still continue to take place through the Pescadero and Hardy rather than through any portion of the abandoned channel of the Colorado.

Conditions in the Estuary

Although normal quantities of suspended matter and bottom drift still pass down the river, a brief consideration of the recent history of the region discloses the rather startling fact that for the past twenty years hardly any of this material has reached its destination in the estuary or the sea but has been trapped and retained either in the delta or the Salton basin, as is shown by the foregoing statement of the river movements during this period. The water that finally reached tidewater has been pretty thoroughly clarified, first by settlement of the suspended matter in lagoon-like areas and thereafter by passage through natural filter screens of dense vegetation.

This, then, is the condition at the present time where sea and river meet. Each succeeding ebb tide draws its toll of previously deposited solid matter from the upper part of the estuary and drops it once more in the wider or deeper regions down where tidal scour is less intense. In the meanwhile the supply of new material from above is virtually cut off, and in consequence the estuary is already altering somewhat in character and configuration. The channel in the vicinity of the former junction of the Colorado and the Hardy is apparently becoming deeper and more definite, making the deep and decisive sweep towards the southwest as in the time of Hardy.

A similar state of affairs has undoubtedly existed upon previous occasions, for with the total diversion of the river water into the Salton basin for a period of years—and the evidence is unmistakable that such diversions have occurred—only comparatively clear water would reach tidewater until a direct channel was once more opened between the upper river and the estuary. We are therefore merely observing at the present time one phase in a well established cycle of events; and the estuary, which is of course the portion of the system most affected by any great change in the volume of silt reaching and traversing the delta, is now reacquiring a character corresponding to the full development of that phase.

It is interesting to speculate somewhat upon the prospect of still greater modifications, especially in the lower portion of the estuary where silt and sea have their final encounter; for it is unlikely that the amount of solid matter reaching tidewater will ever again reach the tonnage of former periods of well established and directly communicating channels across the delta. In addition to the effective obstruction to the free egress of silt which still continues to exist in the basin of the Pescadero, some comprehensive scheme for flood control and water

FIG. 15

FIG. 16

FIG. 15—In the old channel of the Colorado, abandoned since 1909. Photograph taken in 1925.
FIG. 16—On the new delta. Secondary growth of vegetation among the tree tops. The tree is the upper portion of a mesquite. Original surface of ground is some ten feet below present level.

storage will inevitably be carried out upon the Colorado within the next few years, the first effect of which will be the impounding of the greater portion of the solid matter held in suspension in the running water.

The proponents of the Boulder Canyon dam claim a silt storage capacity behind this proposed barrier equal to one hundred years of normal deposition, and any alternative plan carried out below the inflow of the San Juan and Little Colorado is likely to prove at least an equal deterrent. With the cutting off of the supply of silt the shaping of the estuary will depend almost entirely upon tidal action for an indefinite period or perhaps permanently.

The great tides in the head of the gulf have never been fully investigated, and indeed since the brief navigational era they have very rarely come under systematized observation of any description. The first of the flood enters the mouth of the river in the form of a well defined and at times extremely violent bore for several consecutive great daily tides before and after each recurring spring tide. The rise is extremely rapid after the passage of the bore, a gain of over a foot a minute for several consecutive minutes having often been observed in the vicinity of the mouth of the Hardy.

Such a tidal régime will have for its effect a general broadening out and removal of obstructions to the free movement of a great volume of in-rushing water throughout the estuary as the spring tides are approached and passed, with a corresponding tendency towards the development of ebb-swept drainage channels at the time of the neaps. It is obvious that with the virtual cutting off of the supply of sedimentary matter with which the banks of these drainage channels can be replenished the ultimate result will be the scooping out of a large, shallow, and lagoon-like basin in which tidal action will quite overbalance the effect of the clear stream from the river.

A tide may be assumed to have a certain "reach" dependent upon its average height and the gradient of the slope over which material must be transported before the next incoming tide is encountered. It is the length of this reach, or stroke, that governs the position of the bar so commonly existing at the mouth of tidal estuaries, its character being determined by the quantity and quality of the material swept down by the ebb. With the continued lack of detrital matter from above, the channel from the head of tidewater to the bar may gradually lose its canal-like form and its ability to keep itself open to a definite mouth, and the bar itself may become a continuous shoal.

It is possible that similar conditions existing at some former period have resulted in the formation of the Montague-Gore Island barrier, which seems to occupy such an anomalous position in the river mouth, and that the next development will be the gradual formation of a great tidal basin in which the water will probably vary greatly in

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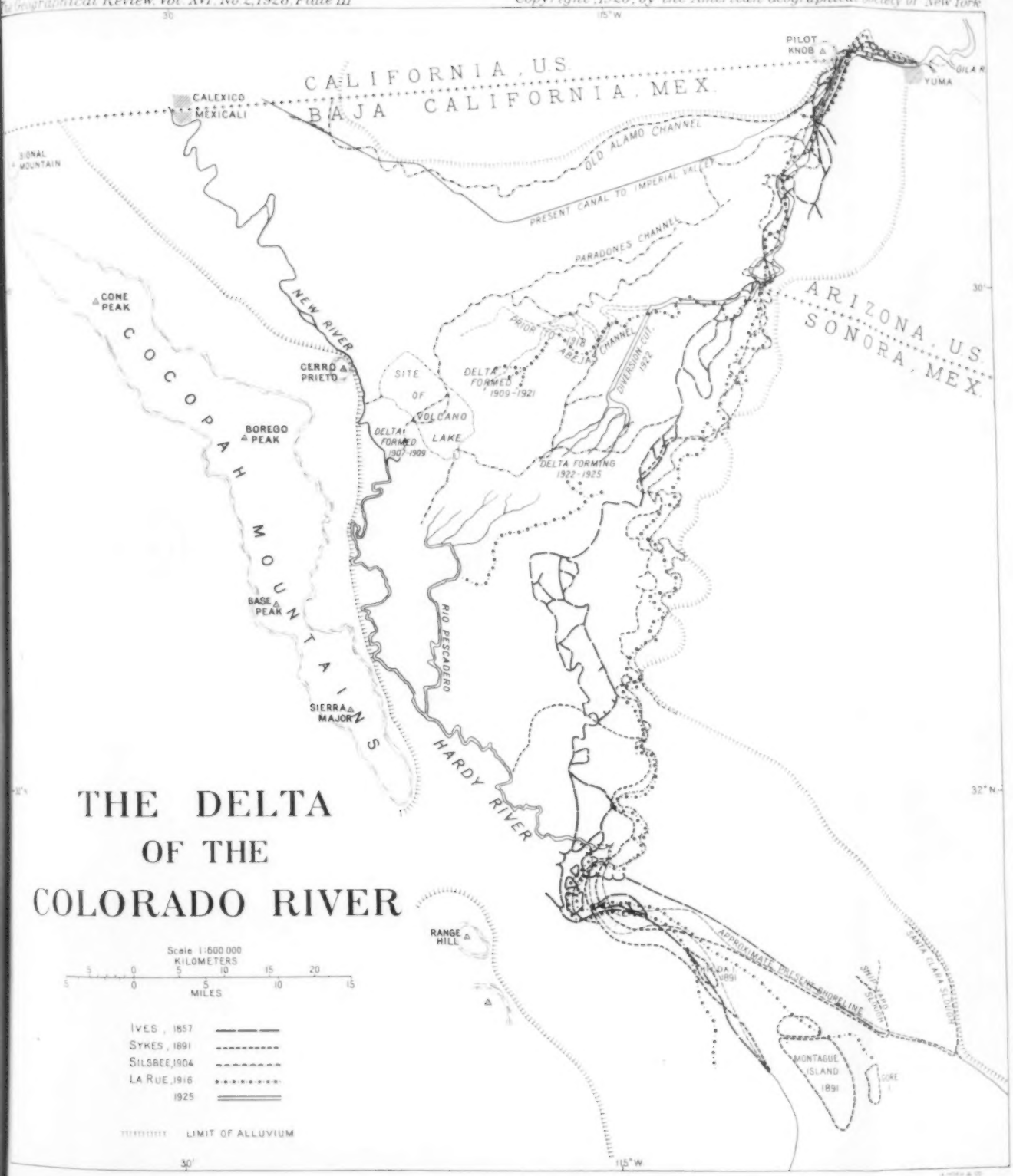

THE DELTA OF THE COLORADO RIVER

Scale 1:600 000
KILOMETERS 5 0 5 10 15 20
MILES 5 0 5 10 15

IVES, 1857
SYKES, 1891
SILSBEE, 1904
LA RUE, 1916
1925

LIMIT OF ALLUVIUM

salinity according to the season of the year and the amount of water reaching it from above, while the barrier will reform somewhat farther down the gulf in accordance with the general growth of the delta since the last total diversion of the load of silt occurred.

Scientific and Economic Interest

At the present time there is again some commercial activity at the mouth of the river. A small steamer, carrying passengers and light freight, now runs to and from Guaymas on a rather elastic schedule, taking the place of a predecessor that was capsized and lost in the bore a year or two ago with an appalling loss of life. There is also in contemplation and, in fact, in part under actual construction a railroad which is planned to serve the great cotton and other agricultural interests in the Mexican portion of the delta and to have as one of its objectives a port either in the estuary or at some other suitable location at the head of the gulf. Other schemes, rather more nebulous and involving the drilling of wells, the building of levees in the lower delta, and the reclamation of various desert areas down the peninsula shore, are also in the air and will probably eventually materialize at least in part and so bring under human occupation a region that has hitherto remained in much the same condition as when first visited by the Spaniards in 1541.

From a scientific point of view it would seem to be in every way desirable that such a full-sized geographical problem—a great river passing through a most interesting phase of development almost within hail of civilization and yet in such a manner as to be almost entirely unhampered by human interference—should be kept under close scrutiny by trained observers, at least until its further elucidation has become an accomplished fact.

THE UNIVERSITY OF MICHIGAN GREENLAND EXPEDITION OF 1926–1927

William Herbert Hobbs

University of Michigan

THE expedition to Greenland under the auspices of the University of Michigan will have for its primary purpose the study by quantitative observational methods of the glacial anticyclone which overlies the continental glacier or "ice cap." This study will be undertaken from meteorological stations to be set up both on the glacier itself and outside its margin, and these stations it is expected to maintain for the period of about fifteen months.

Personnel of the Expedition

The expedition will be conducted by the head of the department of geology and will include in its personnel some twenty persons, mostly from the University but with distinguished explorers and scientists from other universities and from government bureaus. The veteran Danish explorer, Peter Freuchen, and the distinguished physicist and expert on icebergs, Professor Howard T. Barnes of Montreal, will each be in charge of a special part of the work undertaken. Associated with Professor Barnes will be Mr. Vibert Douglas, who was with Sir Ernest Shackleton on his last expedition and is now an instructor at Harvard University. Another member of the expedition with Arctic experience is Dr. Walter Koeltz, who accompanied the last MacMillan expedition to North Greenland in the capacity of field naturalist. Though the services of Dr. Koeltz are loaned by the U. S. Bureau of Fisheries, he is a graduate of the University of Michigan and will be in charge of zoölogy on the expedition. Others from the University of Michigan on the staff of the expedition are Dr. Laurence M. Gould, Mr. Ralph Balknap, and Mr. William A. Clark of the Department of Geology, and Mr. Carl O. Erlanson, instructor in botany.

Dr. Charles F. Marvin, chief of the U. S. Weather Bureau, is giving important support to the expedition by loaning for the summer of 1926 the services of Mr. S. P. Fergusson and, in addition, by supplying the meteorological equipment for the several stations so far as this can be done from the reserve stock of the Bureau. Mr. Fergusson has devised much special meteorological apparatus, notably in self-registering instruments and in the improvement of the technique of

balloon work, and he has further had experience in setting up and maintaining the high altitude station of the Bureau on Mt. Rose, Nevada.

Colonel Lester E. Jones, director of the U. S. Coast and Geodetic Survey, has loaned surveying instruments to fix the location and the altitude of all meteorological stations, including one to be placed high up on the ice cap and about one hundred miles within its border. Nothing of this kind has ever before been attempted, and some special technique may be necessary.

The expedition expects to leave the United States in late June or early July on a special chartered vessel and will lay down its main base within the Holstensborg district of Greenland on the east side of Davis Strait and close to the Arctic circle (see Fig. 1), after which the ship will return. The greater part of the expedition's personnel will return to the United States in October and return to Greenland again in the early summer of 1927. Those who are to be in charge of meteorological stations and the aviation personnel will remain in Greenland until October of 1927.

FIG. 1—Map of Greenland showing routes of explorers across the ice cap and the positions of projected stations of the University of Michigan Expedition.

THE GLACIAL ANTICYCLONE

The meteorological stations which it is planned to establish and maintain for the period of more than a year are four in number, three of which are to be occupied and the other visited fortnightly for the purpose of resetting instruments. In order to explain the selection of their sites it will be necessary to discuss in briefest outline the operating mechanism of the glacial anticyclone of Greenland which it is proposed to study.[1]

The glacial anticyclone of Greenland, except within the near-marginal zone, is an auto-circulation which consists of (1) a central area of calms and light shifting winds characterized by high relative

[1] See, among other papers by the author, "Characteristics of Existing Glaciers," New York, 1911, Chapters 9 and 16; "The Rôle of the Glacial Anticyclone in the Air Circulation of the Globe," *Proc. Amer. Philos. Soc.*, Vol. 54, 1915, pp. 185–225; "The Mechanics of the Glacial Anticyclone Illustrated by Experiment," *Nature*, No. 2647, Vol. 105, 1920, July 22, pp. 644–645; also a forthcoming monograph of 200 pages entitled "The Glacial Anticyclones: The Poles of the Atmospheric Circulation," to be published by the University of Michigan and now in press.

humidity, by snow fogs, and by sublimation phenomena as well as by extreme low temperatures and (2) an upper-slope area perhaps a hundred miles wide on the average, which is characterized by irregular pulsational (*strophic*) outrushes of down-slope winds which produce storms of exceptional violence. On the west coast these outrushes of air come in general from the southeasterly quadrant, but on the eastern coast they come from the northwesterly. No such low temperatures are encountered in this upper-slope area as are found within the interior. At the conclusion of each blizzard the air temperature rises rapidly at the ice-cap margins through an accentuated fall-wind effect (föhn). The outrushing hurricane winds override the air at the lower levels about the margins of the ice cap, so that deep down in the valleys and fiords there is a large measure of protection afforded. The level below which the stronger winds seldom reach, particularly during the summer season, is near the 1000-meter contour. It is for this reason that the Danish weather stations on the fiords preserve little record of these fierce winds during the summer season, and some of them during the winter as well.

The Meteorological Stations

The two main meteorological stations of the expedition are to be located, one of them outside the ice cap on the inner part of the coastland ribbon and at an altitude (to be accurately determined) in excess of 1000 meters, the other within the windy upper-slope area upon the ice cap and at an elevation of about 2500 meters. Secondary to this main ice-cap station there will be another station farther in upon the ice plateau and within the area of calms and light shifting winds. These two ice-cap stations must be within reach of each other so that the inner one may be visited from the main station at fortnightly intervals.

These unique weather stations will be in charge of Peter Freuchen, whose experience in Greenland exploration and whose physique together make him the most fit man for such a difficult undertaking. It was he who took charge of the isolated meteorological station of Pustervig on the Danish Northeast Greenland Expedition of 1906–1908, and he was later second in command on the long and arduous Arctic expeditions of Knud Rasmussen. He was governor at one time of the Thule colony in north Greenland, and his experience as a Greenland explorer extends over eighteen years.

The fourth meteorological station of the expedition will be located deep down in a protected valley near the main land station and in connection with the hangar for the two planes.

It is to be expected that the winds encountered at the principal land station of the expedition will not differ greatly in violence from

those described from the Antarctic by Sir Douglas Mawson in his "Home of the Blizzard," and special means will be employed to anchor the station firmly to the rock beneath. In all stations the meteorological apparatus will be installed in the roof of the hut to avoid the hardships of visiting during the fierce blizzards which sometimes continue for days on end. In the construction of the huts wind-proof and heat-insulating materials will be employed, and the hut upon the ice cap will also be partly sunk in the snow. It is believed to be almost certain

FIG. 2—Character of ice-cap surface of Greenland suitable for landing of planes (after Peary).

that, during the winter, temperatures will be measured at the inner ice-cap station far below any as yet recorded anywhere on the globe. The fixing of the altitude of both ice-cap stations by methods independent of the aneroid will make it possible for the first time to secure reliable values for air pressures over either of the continental glaciers.

Of the utmost importance is a study of irradiation from the inland-ice surface at both the ice-cap stations, and the instrument used by Dr. Harald Sverdrup on the *Maud* has been promised the expedition by the Astrophysical Observatory of the Smithsonian Institution. It will be fitted with a self-registering device in order to take observations continuously.

LOCUS AND EQUIPMENT FOR COMMUNICATIONS

The Holstensborg district within which the expedition is to make its observations lies within much the widest section of the coast-land ribbon of Greenland. This section of land now uncovered by the ice is about one hundred miles in width and nearly twice as long, and except for a few deep fiords all the southern portion is practically a blank upon the map. Fortunately we know something of its characteristics within the belt lying east of Holstensborg Settlement from the penetration made by Professor Otto Nordenskjöld during the summer of 1909.[2] Nordenskjöld found the country nearest the sea to have an

[2] Otto Nordenskjöld: Einige Züge der physischen Geographie und der Entwickelungsgeschichte Süd-Grönlands. *Geogr. Zeitschr.*, Vol. 20, 1914, pp. 425–441, 505–524, and 628–641.

alpine character, but he passed from this into a region from which the continental glacier had evidently retired, leaving gradual slopes and lakes scattered in great numbers throughout. This region was so dry and warm as to be classified as "steppe" and to have a considerable proportion of salt in the lake waters. It is within this region that the outer stations will be located.

The equipment of the expedition will include a snow motor, to be furnished by the Snow Motor Company of Detroit for transportation over both land and snow, and two amphibian planes. The planes are of special construction designed by the Aerial Service Corporation of Hammondsport, N. Y. The personnel will be for one plane only, the second plane being taken with a view to replacing any needed parts in the other. The planes will be fitted for photographic apparatus, and an expert air photographer and engineer will be included in the personnel to make air surveys of the large tract of country surrounding the stations, of the neighboring portion of the inland ice, as well as a strip some ten miles in width along the route to the ice-cap stations. This route will be marked out by snow huts, which will be useful as a guide for moonlight flights during the winter season. The planes will be used to carry in to all stations fresh food from the cannery settlement at Holstensborg; and this may be important, particularly late in the period of maintenance, to prevent any attack of scurvy in the personnel of the ice-cap station.

It is hoped to accomplish what, so far as known, has not yet been done, namely, taking off and landing on water and snow during the same flight. The surface of the ice cap, except within the outer 50 miles, is smooth and nearly level snow over vast areas (see Fig. 2), and in summer the myriads of lakes on the land outside its border remain open. In winter, when these lakes are frozen and covered with snow, skis will be used exclusively, as they are now used extensively in Canada during the winter season. The sun compasses which proved so useful to the fliers of the recent MacMillan expedition and were furnished by Mr. Albert H. Bumstead, cartographer of the National Geographic Society, have been promised also for the University of Michigan expedition. In one of the protected valleys near the main outer station of the expedition a simple hangar will be erected in which to house the two planes and the snow motor.

The planes will also be employed for altitude flights with meteorograph to determine the high-level conditions above the inland ice, though parallel observations will be made from the stations with both pilot and "free-captive" types of balloon. Up to the present no upper-air work has been attempted over the inland ice, though observations have been made outside its borders.

The stations will be connected by radio and with the Danish stations with radio equipment at Godhavn and Godthaab. Dr. La Cour,

director of the Danish Government Meteorological Institute, has offered cooperation with the stations at both the above-mentioned settlements and also at Angmagssalik on the southeast coast of Greenland. It is hoped also that connection will be maintained with Dr. Lauge Koch's base on Scoresby Sound, on the east coast.

The Winds

It is of much importance that frequent observations of the direction and rate of movement of upper clouds should be made at all

Fig. 3—Character of coast-land ribbon where outer stations will be set up (after O. Nordenskjöld).

meteorological stations not too remote from Greenland. Of the first importance will naturally be all stations on the Greenland coast, the Norwegian station on Jan Mayen, the Danish stations in Iceland, and the British stations in the outlying Orkneys and Hebrides. It is known that at most of these places the upper clouds, at least during the winter season, have a dominant movement in the direction of Greenland and against the trend found otherwise to characterize the north temperate zone as a whole. It is not known, but it is highly probable, that these motions in the direction of Greenland are increased whenever the strophs of the glacial anticyclone are in operation. It is even possible, and perhaps probable, that a means of forecasting the times of the Greenland strophs can be found in these movements. If a meteorological station could be established by the Norwegians in Spitsbergen for such observations, it would have a special value because of the strategic importance of the location and because the skies are there much clearer than they are at Jan Mayen.

Inasmuch as the winds of the outer zones on the ice cap are so clearly down-slope winds deviated by earth rotation, the opportunity is here afforded as nowhere else except over the Antarctic continent, for determining directly through observation the amount of deviation for this latitude. The direction of steepest slope can be determined from the surveys on the way to the ice-cap stations, and the angle between this line and the trend of the *sastrugi* can be measured along the route.

The primary purpose of the expedition, it was stated at the outset, is to study the characteristics of the glacial anticyclone of Greenland; but this hardly indicates with sufficient clearness a special direction which the study is designed to take. It appears probable that the pulsational outrushes of cold winds of great violence from their breeding place above the ice cap are the starting points of the storms over the northern Atlantic and Europe.[3] The cyclones which migrate eastward from the United States dissipate their energy over the Atlantic and, unless new energy is imparted to them, arrive in Europe as the "dying cyclones" of Bjerknes. If, however, they pass into the area of control by the Greenland anticyclone near the conclusion of one of its powerful strophs, the energy of the outrushing air from the ice cap is poured into the dying cyclone so that it crosses the northeastern Atlantic and arrives in Europe as a violent storm area—a D, E, or even F cyclone of the families described by Bjerknes and Solberg.[4] A preliminary comparison of the dates of arrival of D and E cyclones at the meridians of 10° W. (Jan Mayen) and of Greenwich, which have been kindly furnished by Professor V. Bjerknes for the year 1922, with the data available from certain favorably located fiord stations of Greenland for that year, seems to indicate that for the winter season the arrival of the fall winds from the interior precedes by from two to four days the arrival of D and E storms on the meridians mentioned. For the summer season, when the strophs are much less powerful, the fiord stations are protected by overriding. In this connection it is of interest to recall that Sir Douglas Mawson found that the maximum outrushes of cold air in Adelie Land preceded by about forty-eight hours the arrival of strong cyclonic storms on the south coast of Australia.

Thickness and Motion of Ice

One of the problems which it is hoped to attack in going over the ice cap is a sounding of the ice to determine its thickness. The "seismo" method has now been brought to a state of high perfection, and one of the oil companies that has been most successful with this

[3] W. H. Hobbs: The Source of the Cold Air of the North "Polar Front," *Nature*, No. 2918, Vol. 116, 1925, October 3, pp. 519–521; see also *idem:* L'asymétrie de la circulation atmosphérique, *Comptes Rendus de l'Acad. des Sci.* [de Paris], Vol. 181, 1925, August 17, pp. 289–290.

[4] J. Bjerknes and H. Solberg: Life Cycle of Cyclones and the Polar Front Theory of Atmospheric Circulation, *Geofys. Publikationer*, Vol. 3, 1922, p. 14.

method has promised the expedition the loan of an instrument and a man familiar with its use. The rocks which the ice cap overlies within the Holstensborg district are crystalline granite and gneiss, which have a velocity for sound of about three miles a second. The velocity of sound in glacier ice is about one-third as much, which makes it probable that good reflection can be secured from the rock bottom to the ice cap.

It has long been assumed, but without warrant, that continental glaciers are shaped throughout by an internal motion of their own in which the entire glacier has a part. It is believed that the internal motion is restricted to the outer marginal zone where alone there are steep surface slopes, and that the shaping of the ice cap is a product of the centrifugal broom operated by the strophs of the anticyclone. The surveys made in the summer of 1926 it is expected to repeat for the marginal portion in the summer of 1927 with a view to throwing light upon this vitally important question. At the same time it is hoped to make studies of the value of gravity above the ice cap by a newly devised and extremely simple device which it is hoped will be available by that time.

The Iceberg Problem

A problem of much promise, but with an extremely difficult technique to be worked out, is that of the icebergs born in Greenland which are such a peril in the navigation of the Atlantic. Dr. Lauge Koch on his American lecture tour in the United States in 1924–1925, several times pointed out that the proper place to attack this thorny problem of the icebergs is their birthplace on the borders of the ice cap of Greenland. By far the greater number of the larger bergs are calved from the great glacier outlets in the fiords east and northeast of Disco Island. There is much to be learned of the first importance concerning the times of liberation of the bergs and the periods which they require to reach the Atlantic travel lanes. This will be the special study of Professor Barnes, who with his associate, Mr. Douglas, will accompany the expedition and make a base at Disco Island. Professor Barnes has long been the foremost authority on icebergs and on anchor and river ice. During the winter of 1924–1925 he succeeded in breaking up an ice jam on the St. Lawrence River which was 15 miles in length and was estimated to contain a million tons of ice.

EARLY MAPS OF CAROLINA

Worthington Chauncey Ford

THE first map of Carolina made by an Englishman, of the then undefined territory south of Chesapeake Bay, was that of John White, who accompanied the Raleigh colony to Roanoke (1585–1587). His map, engraved by De Bry, begins at Chesapeake Bay and extends as far as Caput Tremendum, which became Cape Fear. The detail is of the coast, as was to be expected. Exploration could be made by water, but the size of the party was too small and the attitude of the Indians too unknown to permit land expeditions. Beyond Caput Tremendum lay lands long in dispute between French and Spanish, ground already notorious for massacre and reprisal. At the beginning of the seventeenth century it was held by Spain in virtue of a policy which regarded any intruder as worthy of death. Even the Roanoke region fell under the claims of Spain, and the English who came in 1664 found themselves liable to threats and kidnapping at the hands of the Spaniards at St. Augustine.

The ever present danger discouraged exploration to the southward; and a second map of White, never engraved, covering Virginia and Florida, must be taken either as based upon report or, as was more probable, borrowed from one of the general maps of the coast painfully compiled by professional map makers.[1] The sole interest of this second map lies in the mention of names later to become familiar, but they are placed in hopelessly irreconcilable positions.

The Locke Map

The first map to show any detail of the Cape Fear region is a manuscript in the British Museum, known as the Hilton map (Addl. 5415, G, 4). It was badly reproduced by the Massachusetts Historical Society[2] and was there used merely to establish connection between Hilton and a New England family of the same name. The manuscript is of too great interest to be restricted to clearing a point in genealogy. It carries the memorandum: "Discouery made by William Hilton of Charles towne In New England Marriner from Cape Hatterask Lat: 35: 30′ to the west of Cape Roman in Lat: 32. 30′ In the yeare 1662 And layd Down in the forme as you see by Nicholas Shapley of the town aforesaid Nouember: 1662." I am enabled to identify the writ-

[1] White's map is given in Hakluyt's "Principle Navigations" (12 vols., Hakluyt Society, Glasgow, 1903–05), Vol. 8, facing p. 401.

[2] *Proc. Mass. Hist. Soc.*, Ser. 1, Vol. 20, p. 402.

ing as that of John Locke the philosopher, whose interest in the Carolina plantations through his connection with Shaftesbury is well known. The whole map is his, copied from an original by Shapleigh, now lost.

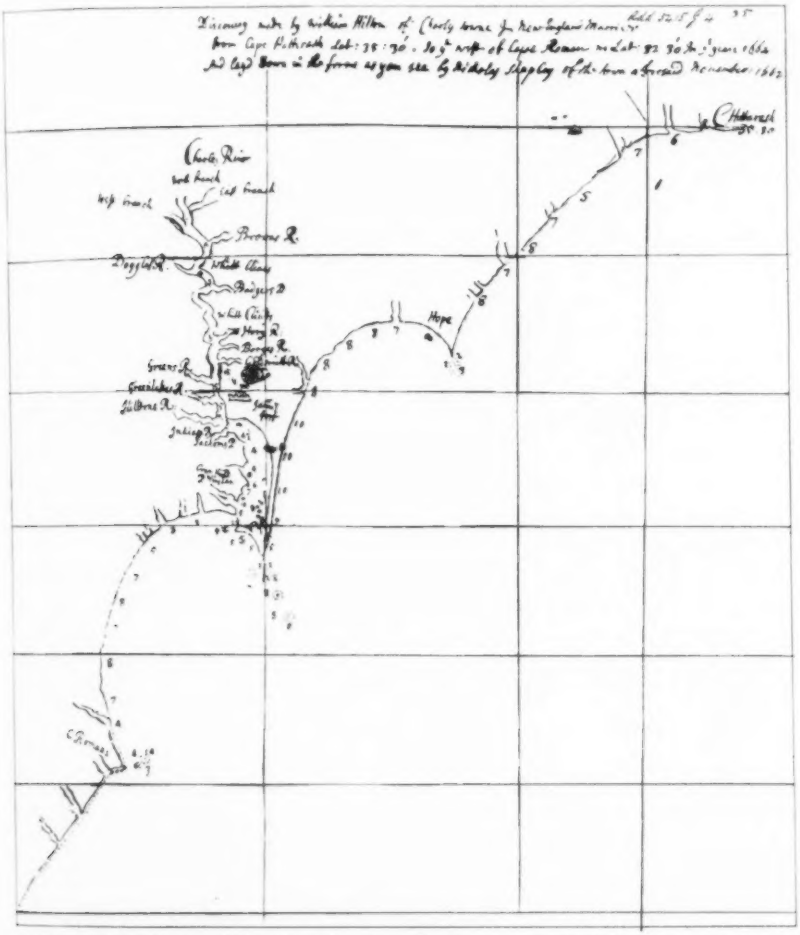

FIG. 1—The Locke map of Carolina, 1662. Reproduced on a reduced scale from a photostat copy.

Apart from this identification the map is of great geographical interest. In 1660 a party of New Englanders had made a settlement on the Charles River at Cape Fear. Claiming the land in virtue of purchase from the Indians and settlement, they invited others to join them and also started to obtain coworkers and subscriptions in London. Unfortunately, while these measures were in process, some who had gone from New England did not like the place and returned "without so much as sitting down upon it; and for the better justifi-

cation of themselves in their return, have spread a reproach both upon the harbour and upon the soil of the river itself."[3] Naturally such reports tended to check adventurers in England and also in the West Indies, where the discontent of those immigrants must have been known before London had become possessed of them. Yet the full meaning of the dissent could hardly have been realized in 1662 when Hilton had gone to Carolina in the interest of some intending settlers from Barbados and New England. This map is the only record of that voyage. Assuming that Locke has included all the details which Shapleigh gave, it is seen that Hilton made no real exploration of the region near to or south of Cape Roman. The dots on the coast line may indicate that he skirted the coast; but soundings do not begin until Cape Roman[4] was reached, and attention is concentrated on the Charles [Cape Fear] River. No other of the many rivers on the coast is given a name, and his vessel entered none of them to examine their possibilities. This map must have been made known both at Barbados and New England, for a party of settlers went to Carolina on the strength of Hilton's report. Unfortunately that report has never been found, and no summary of it exists.

Because of the complaints made by the New Englanders, several gentlemen and merchants of Barbados sent Hilton on a second exploration. It was almost at the same time that the Lords Proprietors also took notice of the complaints, writing: "but some ill-willers to the settlement upon Charles River contrived its miscarriage, and they went not to the branch of the river that Hilton was in, and besides took not the proper time of year."[5]

Hilton sailed in the *Adventure* from Speight's Bay, Barbados, August 10, 1663, completed his exploration, and returned to Barbados January 6, 1664. A report of his proceedings was printed in London in 1664 with the title, "A Relation of a Discovery lately made on the Coast of Florida, . . . London, Printed by J. C. for Simon Miller at the Star neer the West-end of St. Pauls, 1664." No map accompanied this tract.

The Map of 1666

No engraved map of the territory appeared until that issued in the anonymous pamphlet: "A Brief Description of the Province of Carolina on the Coasts of Floreda. And more particularly of a New-Plantation begun by the English at Cape Feare, on that River now by them called Charles-River, the 29th of May, 1664. . . . Together with a most accurate Map of the whole Province. London. Printed for Robert Horne in the first Court of Gresham-Colledge neer

[3] *Mass. Hist. Soc. Collections*, Ser. 3, Vol. 1, p. 58.
[4] An island—Smith Island—is given off Cape Roman.
[5] Lords Proprietors to Modyford and Colleton, August 30, 1663.

Bishopsgate-street. 1666." Horne published manuals and books on trade and also sold medicines which were evidently of the quack-salver's budget. Yet there is reason to believe that the tract appeared at the instance of the Lords Proprietors of Carolina.

This map has been reproduced,[6] yet its significance as giving a stage in the geographical development of Carolina has not been noticed. On comparing it with the Locke manuscript it is seen that few names of localities are the same. The Locke map thus possesses the unique quality of giving the names originally bestowed by Hilton on the Charles River (Cape Fear) region. But the map of 1666 is also a Hilton map, as is proved by its recording only such names as are to be found in the printed account of Hilton's second exploration. Why he should have rejected the larger number of the earlier names is nowhere explained. A comparison of the Locke and the 1666 maps is conclusive. Beginning at the mouth of the river at Cape Fear a parallel may be made, allowance being made for the obvious difficulty of exact locations upon crudely drawn maps. The places are on the east or west side of Charles River, and the names marked with an asterisk are to be found in Hilton's report.

1662 (Locke)		1666	
West	*East*	*West*	*East*
	[Cape Fear]		C. Fear
P. Winslow			
Crane Iland		Charles Town	
Sachoms P[oint]		*Mount Bonny	
Indian R[iver]		*Mount Skarie	
Hiltons R[iver]		*Hilton Riv[er]	
	Januy (?) fort	*Longs Ile	Goose Ile
		*Blowers Ile	
Greenlesses R[iver]			
Greens R[iver]		*Green Riv[er]	
		*Swampy Branch	
	Goldsmith R[iver]		
	Borges R[iver]		
	Hory R[iver]	*Highland P[oint]	
	Whitt Cliffts (?)	*Rocky P[oint]	
	Badger D	*Stagg Park	
Doggles R[iver]	Whitt Clives		
	Browns R[iver]		*Turkey Quarters
West branch	East branch	*Fabian Riv[er]	East Branch
North branch			Pine Plains
Charles Riuer			Pleasant Meadows

On the second voyage Hilton went first to the more southern region and touched land in latitude 32° 30′ N., or about four leagues

[6] In W. C. Bryant and S. H. Gay's "A Popular History of the United States" (4 vols., New York, 1876–1881), Vol. 2, facing p. 284, is given what purports to be a "facsimile"; it is only a clumsily made tracing with the names of places reversed!

north of the Spanish St. Helena, known to the French as Port Royal. Referring to the Carolina map of 1666, it is seen that the names were again taken from Hilton's "Relation"—Granby [North Edisto] River, River Jordan [the Combahee], Charles Fort on one island [Parris], St. Hellens on another, and Port Royal. Most of these, it is true, were really old names; for Jordan River, Cape de Helene, Port Royal, and Grande River are to be found on White's manuscript map of Virginia and Florida.

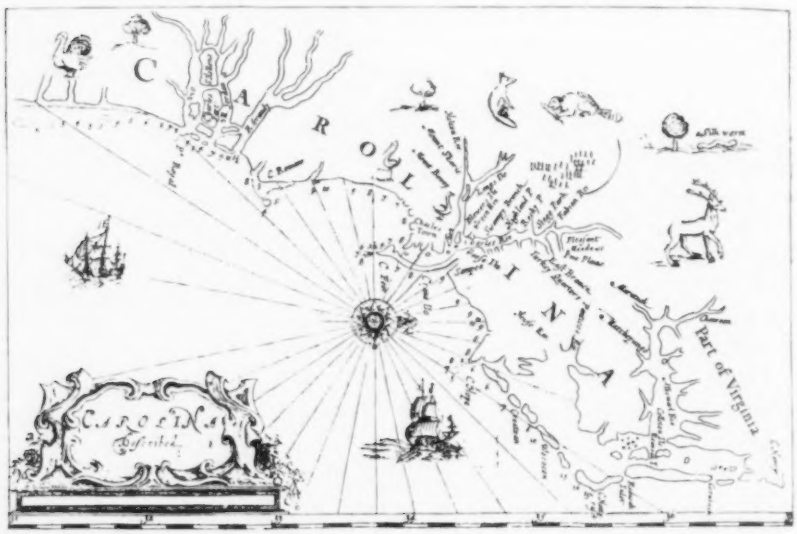

FIG. 2—The 1666 map of Carolina. Reproduced on a reduced scale from a photostat copy.

ADDITIONAL EVIDENCE

I had reached this stage of certainty in my investigations when Mr. Wroth, librarian of the John Carter Brown Library, courteously sent me photostats of two manuscript maps of Carolina in that library. They belonged to a volume of maps brought together by William Blathwayt towards the end of the seventeenth century to assist him in his duties of enforcing commercial laws in the British colonies in North America. The maps are of unquestioned authenticity, and some of them are so curious as to merit reproduction. I was surprised to recognize these two maps as either the originals of the two Hilton maps or, what is more likely, as copies made for Blathwayt from the originals. As maps they are finely drawn, perfect in detail, and of quite unusual merit. They confirm what names and conclusions I drew from the maps of Locke and of 1666; and, as they are clearer, they enable us to give what may be a more proper version of the names. Taking the map of 1662 we have Piomslow land instead of

P. Winslow; Bordges for Borges; and White Claues, twice repeated, for Whitt Clives. The other names are practically the same.

On the map of 1664 we have, on a much finer plan, the same notation as on the engraved map of 1666 except the omission of Goose Ile opposite the mouth of Hilton River and the addition of Longes Delight at the head of Charles River. The engraving gives much outside of Charles River, including names and figures of animals, while the manuscript is severely limited to what was on or in the Charles. The manuscript also gives more detail in the Port Royal region. In addition to what was on the map of 1666 we have: Hilton Head, Blowers River, Longes River, and R. Fabian; and the soundings on the coast run nearly a full degree of latitude to the south of Hilton Head.

The accuracy of a map is tested by time, and Hilton's discoveries may be measured by later maps. In his "List of Maps of America" Phillips gives 1671 as the date of the map next in order of time to that of 1666 and falls into a number of errors. He lists "A New Discription of Carolina. By Order of the Lords Proprietors," engraved by James Moxon, and assigns to it the year 1671. He then indicates that it was taken from Wilson's "An Account of the province of Carolina," which was not published until 1682. He correctly notes an inset draft of Cooper and Ashley River and adds: "Same map in Speed's 'The Theatre of the Empire of Great Britaine,' 1676. Originally made for Ogilby's America 1671."[7]

Maps in Ogilby's "America"

A map of the new territory was a standing order from the Lords Proprietors to the surveyors in Carolina, and they doubtless received more or less imperfect drafts as their surveyors went over the land. Phillips bases his statement on an undated letter of Sir Peter Colleton to John Locke, which the English cataloguer has placed in 1671 but with a question-mark after the year. In it Colleton states that "Ogilby is printing a Relation of the West Indies and wishes to get a map of Carolina. Desires he [Locke] will get of my Lord [Ashley] the maps of Cape Fear and Albemarle, and Colleton will draw them into one with that of Port Royal, and will wait upon my Lord for the nomination of the rivers, etc."[8] Ogilby's "America" was announced in midsummer, 1670, as in preparation for publication in January, 1671; in November, 1670, it was said to be "now in good forwardness," and it was actually published November 3, 1671.[9] Sir Peter

[7] The cataloguer was misled by the fact that the two pictorial features of Ogilby's map—"Virginiæ partis australis, et Floridæ"—were copied on Moxon's plate.

[8] America and West Indies, 1669–1674, No. 714.

[9] Edward Arber: The Term Catalogues 1668–1709 A. D. (3 vols., London, 1903–1906), Vol. 1, pp. 45, 63, 94.

Colleton's letter may therefore have been written in 1670 or 1671 but produced no map, for the list of engravings in the first issue of Ogilby makes no mention of a map of Carolina.[10]

Possibly information obtained by Colleton was embodied in the first or general map of America which appears in Ogilby, engraved by F. Lamb. It is entitled: "Novissima et Accuratissima Totius Americæ Descriptio per Johannem Ogiluium Cosmographum Regium," is dedicated to Lord Ashley, and has his arms. On the coast of North America are found, and probably for the first time on such a general map, the names: C. Fear and C. Carteret, with Barkly and Ashley Rivers; R. Jordan, P. Royal, and Hilton Head. Between Cape Carteret and Jordan River a name has been erased—it marked a cape, for C [Carteret?] is plainly seen—and along the Jordan a name has been treated in the same manner—probably "Craven."

A bit of evidence in favor of this supposition, that Colleton's information was embodied in the general map, is to be found in the map "Virginiæ partis australis, et Floridæ partis orientalis, . . . Nova Descriptio" in Ogilby. Strong in detail so far as [North] Carolina is concerned, from Cape Fear to Cape Romano only three names appear, and not one of them was due to the English occupation. Not the slightest hint is given of colonization and naming of localities. A second piece of evidence is to be found in the text. Colleton, in the same letter, said: "if Locke would do them the favour to draw a discourse to be added to this map in the nature of a description such as might invite people without seeming to come from us, it would very much conduce to the speedy settlement, and be a very great obligation to the writer." No such description can be traced; but Chapter II, Section V, concerns Carolina, and page 212 gives an outline of the "model drawn up by Lord Ashley." It is only the briefest outline, and that page is in a smaller size of type and is the only page so treated in the entire volume. That brevity, incomplete in meaning, and the crowding onto a single page suggest a late insertion, made after the book had been put into type, and so match, as it were, the erasure of names in the Carolina region on the general map of America.

Even the map of Virginia and Florida was not in the first issue of "America"; neither that nor the "Arx Carolina," representing the fort at Charles Town, is called for in the "Directions for placing the Whole-sheet Prints in this Volume of America." A blank space is left in the list where the titles of the two would naturally appear.

[10] Instructions issued by the Lords Proprietors, May 1, 1671, contained the injunction to "send a description of Ashley and Wando Rivers, drawn by a compass to a scale, and a map of the country divided into squares of 12,000 acres apiece by lines running east and west, north and south." Before the end of the year Culpeper had sent drafts of Ashley, Cooper, and Colleton Rivers, showing Charles Town, Waping, and Comings Point. He had not attempted to make a general map of Carolina but had confined himself to the Ashley-Cooper Rivers region. The inset in Moxon's map shows Comings Point but does not have Waping, and not till the Gascoyne map of 1682 is Wappoo Creek to be found. This may, however, be the "Ston Cr." of Moxon's inset.

In a later issue, but with the year 1671 on the title unchanged, both are found, and the blank lines in the "Directions" are filled. Only two maps in the volume are by Lamb—the general map and one of Jamaica.

Ogilby is largely a translation of Montanus' "De Nieuwe en Onbekende Weereld," published at Amsterdam in 1671 by Jacob Meurs. The extract from the privilege granted by the States of Holland and West Vrieslandt was dated July 28, 1670, shortly after Ogilby had announced his "America" as in process of making. Agreement must have existed between Meurs and Ogilby, and nearly all of the Dutch plates were used in the English edition. Which came first from the press? It has been seen that the first edition of Ogilby did not have the Carolina items. Meurs has both (pp. 99 and 142). Ogilby has (p. 337) a map of Jamaica, dated 1671, prepared by himself and engraved by F. Lamb. This is not in Meurs. The general map is not the same. That in Meurs is much more labored and better finished, in spite of the larger number of names which are crowded on seacoast and in interior. On the Carolina coast can be read C of Feare, Cavaruwac [C. Carteret?], and Port Royal. At Port Royal is a Charles River, but Carolina does not appear. In Ogilby the plate of Meurs was worked over, and the Carolina names added to the exclusion of many on the Meurs map. As to text Montanus has no chapter on Carolina, and the plate "Arx Carolina" is inserted in the Florida chapter. The word Carolina does not even occur in the elaborate index. Dapper's German issue of Montanus (1673) has the same features as Meurs. It is safe to say that a separate map of Carolina found in any copy of Ogilby is there as an insert and was not issued with the printed volume. Two such copies are in the New York Public Library, containing the Moxon map; but in neither instance can it be asserted that the map properly belonged to the volume, and all probability is against its being rightfully there.

The Moxon and Lamb (1676) Maps

Phillips states that the Moxon map is the same as that in Speed's "Theatre," 1676. A map of Carolina does appear in Speed with the legend "A New Description of Carolina," without a year; but it was engraved by Francis Lamb and had no inset of the Cooper and Ashley Rivers. The copy now before me states that it was "Sold by Tho: Basset in Fleet street, and Ric: Chiswell in St. Paul's Churchyard."[11] It is known that the "Theatre" had been out of print since the great London fire. In February, 1675, a reprint was announced in the "Term Catalogues" by the two publishers just mentioned, and a year later the book was on the market.[12] So far as Speed was con-

[11] As in other maps in Speed.

[12] Arber, Term Catalogues, Vol. I, pp. 202, 229.

cerned the Lamb map could not have appeared before 1676. It is possible that Lamb did have his material from Colleton in 1671 and that it was intended to have his map in Ogilby. It was not so used and shows such a distinct advance in the knowledge of Carolina that I do not accept the assertion of its being "originally made" for Ogilby as established. If it had been thus intended why did it not appear in the later issues of Ogilby instead of the poor substitute of Virginia and Florida? Certainly Moxon's map is quite different from Lamb's and could not have been issued as early as 1671: as Lamb does not have the inset, it is probably an earlier map than Moxon's.

Moxon's map is to be found in Wilson's "Account," 1682; and that, it might be supposed, should determine the year to be given to it. But the "Year Book of Charleston, South Carolina," 1886, gives the Moxon map with the legend: "A new description of Carolina By Order of the Lord Proprietors 1672." The original, it is stated, is in the collection of Dr. Thomas Addis Emmet of New York. Except for the year, it is the same plate as appeared in Wilson and so has the inset of the Cooper and Ashley Rivers. Here is encountered one of the overzealous and misleading acts of an enthusiast. Mr. Lydenberg, of the New York Public Library, writes that the year "1672" is entered in lead pencil on the Emmet map; so the Charleston reproduction erred in making it a part of the legend.

Comparing the map of 1666 with that of 1676 (Lamb's), it is seen that the names given by Hilton have almost disappeared. The Charles has become the Clarendon River, and on it are found: Cranes and Long Islands, Turkey Quarters, and Stag Park. The three branches at the source have become a single stream labeled Longs Delight. The region forms part of Clarendon River. Near Port Royal the coast and details have been much extended. The Cooper and Ashley Rivers are shown, with Charles Town on the former. To the south we have the R. Grande and the Ashpow als Colleton River with Lock Island at their mouths, the R. Jordan with Cary Island at its mouth, Port Royal, and Hilton's head. The region has become Berkeley and Craven Counties. In this way Hilton River of the Cape Fear district had dropped its name, and the discoverer is commemorated in Hilton's Head in the Port Royal region. Who thought of the early explorer so far as to perpetuate his name? It is possible that Hilton had in 1662 made a fuller discovery of the Port Royal region and immortalized himself. If so, it is difficult to explain Locke's omission to give the detail of the more southern rivers.

Moxon closely followed Lamb, adding no names but giving a new location to Linhaven and omitting Smith's Island in Virginia. The workmanship is by no means so good as Lamb's, and it would be interesting to know certainly whether Moxon had Lamb before him or both worked from the same original.

Gascoyne's Map

In the year 1682, the year assigned to Moxon's map, Joel Gascoyne of "Wapping Old Stayres" issued "A New Map of the Country of Carolina," also by order of the Lords Proprietors but differing greatly from the Moxon plan. At Cape Fear only Longs and Cranes Islands recall the Hilton names, and the river is hesitating over its own title, for it is called "C. Fear R. or Clarendon R." Charlestown has been restored, and the line of the river is better developed. The Port Royal region is greatly modified, and the Lords Proprietors evidently had that settlement in mind when they ordered the map. Names of holders of lands are given; the rivers have not taken on new titles, save that the Colleton has rejected Ashpow as an alias and the Craven has become the Cambahe; though the Jordan, which has dropped out, has been accepted as the Cambahe. In the inset the island at the mouths of the Cooper and Ashley Rivers bears the name "Sulivant" Island for the first time. Why two such dissimilar maps as the Moxon and the Gascoyne should have been issued by the Lords Proprietors in the same year is a question not to be solved. Both claim the stamp of official authority; but Gascoyne has the greater weight, as his map was accompanied by a printed "Description" intended to be attached to the lower edge of the map and, in the fashion of the day, to serve as a folder for intending emigrants.

If my statements and conjectures are valid, it appears that all memory of Hilton's visits had passed twenty years after they were made, except for Hilton's Head, which he may not have so named, and the two islands, Longs and Cranes. Were they named because of shape or natural features, or after two of his companions? Anthony Long was a companion. Other members of the exploration find place. Pyam Blowers (Blowers Ile) was a master, and Peter Fabian (Fabian River) was a companion. Crane, Green, and Greenless are too vague to be recognized, for they fit natural conditions even more readily than persons. But Winslow (or Piomslow), Goldsmith, Hory, Borges, and Brown suggest persons, and a Master John Hancock was on the second adventure. It is enough to have indicated the historical interest of the Locke and 1666 maps of Carolina and to have offered a solution of the difficulties embodied in the note in the useful "List of Maps of America."

CLIMATIC PULSATIONS DURING HISTORIC TIME IN CHINA

Co-Ching Chu

National Southeastern University, Nanking, China

THE question of climatic change in historic times has called forth investigations in many regions. Recently the writer has made an examination of Chinese archives for material bearing on the problem.

Exact meteorological observation goes back only a short time in any country; but, in the absence of rain-gauge and thermometer readings, we may resort to records of the frequency of floods and droughts, the number of severe winters, the dates when the rivers were frozen over, etc., for hints regarding the climate of the time. It was partly on such data that Brückner based his well-known monograph on "Klimaschwankungen." In dealing with the records in Chinese history there is one advantage which is probably not possessed by any of the European countries, i. e. the length of time for which they are available.

Droughts and Floods

The number of droughts and floods recorded during the time considered have been tabulated first according to Chinese dynasties, Tables I and II, and then according to centuries in the Christian era, Tables III and IV. Since Chinese dynasties are not of equal length, in order to make them comparable the data in Tables I and II have been reduced to droughts and floods per century. The data for the Ming Dynasty (1368–1643) and earlier dynasties are taken from the Tu Shu Tsi Cheng (Chinese Encyclopedia),[1] while those of the Manchu Dynasty are obtained from Tung Wah Loh. In the Tu Shu Tsi Cheng a distinction is made between floods directly due to excessive rain and those caused by the inundation of rivers or overflow of ocean and seas. In Tung Wah Loh no such demarcation can be made out. It is largely due to this difference that the floods recorded under the Manchu Dynasty (1644–1911) as shown in Tables II and IV are especially numerous.

[1] A brief account of this work is given by Hosie, who also has tabulated the droughts and floods. However, he does not make a detailed computation of the geographical distribution—a difficult matter, because the boundaries of the Chinese provinces changed very often from one dynasty to another (Alexander Hosie: Droughts in China, A. D. 620 to 1643, *Journ. North China Branch of the Royal Asiatic Soc.*, Vol. 12, 1877, pp. 51–89. See also "Floods in China 630–1630," *China Rev.*, Vol. 7, 1878–79, pp. 371–372).

The number of droughts and floods in each dynasty or century should indicate to a certain extent the relative deficiency or excess of precipitation at that period. However, beside the point mentioned

TABLE I—NUMBER OF DROUGHTS PER CENTURY OBSERVED DURING DIFFERENT DYNASTIES IN CHINESE HISTORY

DYNASTY	TANG	FIFTH DYNASTY AND NORTH SUNG	SOUTH SUNG	YUEN	MING	MANCHU
Christian Era	*618–907*	*908–1126*	*1127–1279*	*1280–1367*	*1368–1643*	*1644–1847 1861–1900*
Capital	*Chang-an Shensi*	*Kai-fung Honan*	*Hangchow Chekiang*	*Peking Chihli*	*Peking Chihli*	*Peking Chihli*
Chihli	2.1	9.1	9.9	29.9	5.1	26.9
Shangtung	3.4	3.7	6.6	8.1	4.0	19.0
Shansi	4.5	2.3	5.3	19.6	13.8	7.3
Honan	4.2	24.2	5.3	21.9	2.9	12.4
Shensi	4.5	6.9	5.3	12.7	7.3	9.5
Kansu	0.4	1.4	0.7	5.8	0.7	7.0
Szechwan	1.7	—	9.2	2.3	1.5	0.4
Hupei	1.7	2.3	4.6	12.7	16.0	11.2
Hunan	1.7	2.7	4.0	6.9	5.1	8.7
Kiangsi	1.7	0.9	6.6	3.5	4.4	13.6
Anhwei	4.5	7.8	9.9	4.6	2.2	14.5
Kiangsu	4.2	4.1	14.5	10.4	3.3	15.7
Chekiang	3.1	4.1	15.2	6.9	16.7	13.9
Fukien	1.4	1.4	5.9	4.6	7.6	3.7
Kwangtung	—	—	1.3	4.6	2.9	0.8
Kwangsi	—	0.5	—	6.9	4.7	2.1
Yunnan	—	—	—	—	6.5	0.8
Kweichow	—	—	—	—	1.1	—
Manchuria	—	—	1.3	2.3	—	2.1

TABLE II—NUMBER OF FLOODS PER CENTURY OBSERVED DURING DIFFERENT DYNASTIES IN CHINESE HISTORY

DYNASTY	TANG	FIFTH DYNASTY AND NORTH SUNG	SOUTH SUNG	YUEN	MING	MANCHU
Christian Era	*618–907*	*908–1126*	*1127–1279*	*1280–1367*	*1368–1643*	*1644–1847 1861–1900*
Capital	*Chang-an Shensi*	*Kai-fung Honan*	*Hangchow Chekiang*	*Peking Chihli*	*Peking Chihli*	*Peking Chihli*
Chihli	2.1	6.9	3.9	25.3	1.8	43.7
Shangtung	1.7	5.5	0.7	20.7	2.2	27.7
Shansi	0.7	2.3	—	4.6	7.3	12.3
Honan	4.2	17.8	1.3	34.4	2.2	26.0
Shensi	9.1	1.8	3.9	4.6	2.2	11.6
Kansu	0.3	1.8	1.3	5.7	—	8.3
Szechwan	0.7	—	2.6	—	1.1	2.9
Hupei	0.3	0.9	4.6	4.6	0.7	26.2
Hunan	—	1.4	—	3.4	1.1	20.6
Kiangsi	0.7	1.4	5.9	4.6	1.5	21.8
Anhwei	0.7	3.7	5.9	4.6	—	36.3
Kiangsu	1.4	2.7	9.9	3.4	1.5	43.8
Chekiang	1.4	1.4	17.8	4.6	4.0	22.7
Fukien	—	0.9	4.6	4.6	3.3	6.5
Kwangtung	—	0.5	0.7	2.3	1.5	7.0
Kwangsi	—	0.5	—	1.2	0.7	1.6
Yunnan	—	—	—	—	6.9	2.5
Kweichow	—	—	—	—	—	2.5
Manchuria	—	—	—	3.4	0.7	7.8

TABLE III—NUMBER OF DROUGHTS IN DIFFERENT PROVINCES OBSERVED DURING HISTORICAL TIMES IN CHINA*

(By Centuries)

A. D.	0 – 100	100 – 200	200 – 300	300 – 400	400 – 500	500 – 600	600 – 700	700 – 800	800 – 900	900 – 1000	1000 – 1100	1100 – 1200	1200 – 1300	1300 – 1400	1400 – 1500	1500 – 1600	1600 – 1700	1700 – 1800	1800 – 1900	
Chihli	—	—	2	1	—	1	3	2	1	6	14	3	23	16	7	5	13	8	47	152
Shangtung	1	—	1	1	—	—	5	1	3	5	2	4	8	6	5	4	11	8	30	95
Shansi	—	1	1	1	—	1	4	1	5	5	1	1	12	10	7	8	17	3	12	90
Honan	5	14	—	—	2	1	3	1	8	30	23	2	12	12	4	3	9	2	20	151
Kiangsu	—	1	—	3	6	1	1	2	9	4	2	17	10	6	3	4	11	5	24	109
Anhwei	—	—	—	—	—	—	1	2	10	5	7	18	2	4	3	2	9	5	22	90
Kiangsi	—	—	—	—	—	—	—	—	5	1	1	5	6	2	2	9	21	—	12	64
Chekiang	—	—	—	1	—	—	—	1	8	2	4	19	7	6	14	22	20	8	15	127
Fukien	—	—	—	—	—	—	—	1	3	—	—	6	6	4	4	13	6	5	2	50
Hupeh	—	—	—	—	—	—	2	—	3	2	2	5	5	10	15	23	17	4	14	102
Hunan	—	—	—	—	—	—	—	1	4	2	2	7	2	5	9	4	11	—	11	58
Shensi	—	—	2	—	1	4	5	5	3	6	8	6	6	9	7	9	9	1	16	97
Kansu	—	—	—	1	—	—	—	1	—	—	—	4	—	5	1	1	1	6	9	29
Szechwan	—	—	2	—	—	—	5	—	—	—	2	10	4	2	2	2	—	1	—	30
Kwangtung	—	—	—	—	—	—	—	—	—	—	—	—	3	3	2	6	1	—	2	17
Kwangsi	—	—	—	—	—	—	—	—	—	1	—	—	—	5	2	7	3	1	4	23
Yunnan	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2	10	6	—	1	19
Kweichow	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2	1	—	—	3
Fengtien	—	—	—	—	—	—	—	—	—	—	—	2	1	1	—	—	—	1	4	9
Kirin	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Helungkiang	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	2	3
Sinkiang	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2	2
Mongolia	—	—	—	—	1	—	—	—	—	—	—	—	3	—	—	—	—	1	—	5
Kokonor	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	1	2
All China	25	35	24	41	37	41	43	41	43	64	69	58	77	60	54	84	82	36	70	984

*In some cases the phenomenon covers more than one province, while there are a few cases where location is not given; hence the sum for the different provinces in a century is not identical with the number given for the entire country.

TABLE IV—NUMBER OF FLOODS IN DIFFERENT PROVINCES OBSERVED DURING HISTORICAL TIMES IN CHINA*

(By Centuries)

A. D.	0 – 100	100 – 200	200 – 300	300 – 400	400 – 500	500 – 600	600 – 700	700 – 800	800 – 900	900 – 1000	1000 – 1100	1100 – 1200	1200 – 1300	1300 – 1400	1400 – 1500	1500 – 1600	1600 – 1700	1700 – 1800	1800 – 1900	
Chihli	—	2	2	—	—	—	2	2	2	5	9	4	7	18	3	1	24	31	52	*164*
Shangtung	—	3	2	1	2	1	1	1	3	8	4	—	2	17	2	2	14	20	35	*118*
Shansi	—	1	—	—	1	—	—	1	1	1	4	—	1	3	5	12	6	2	24	*62*
Honan	2	10	7	1	1	—	3	6	3	15	19	5	6	26	3	2	14	19	31	*173*
Kiangsu	—	—	1	1	10	—	1	1	2	3	3	13	2	3	3	2	28	37	41	*151*
Anhwei	—	—	2	1	1	—	1	1	—	4	4	6	3	4	—	—	15	31	42	*115*
Kiangsi	—	—	—	—	—	—	1	1	—	—	3	8	2	4	—	1	19	8	28	*75*
Chekiang	—	—	—	—	2	—	1	1	2	—	2	18	10	5	3	4	13	16	27	*104*
Fukien	—	—	1	—	—	—	—	—	—	—	2	6	1	2	4	3	8	2	8	*37*
Hupeh	—	3	2	—	—	—	—	1	—	2	—	5	2	4	—	2	13	14	36	*84*
Hunan	—	3	—	1	—	—	—	—	—	3	—	—	—	4	—	2	10	7	33	*63*
Shensi	—	2	1	—	—	1	4	13	8	1	3	4	3	3	—	6	9	5	14	*77*
Kansu	—	1	—	—	—	—	—	—	—	3	—	3	—	5	—	—	1	2	17	*32*
Szechwan	—	—	1	—	—	—	1	—	1	—	—	4	—	—	1	—	4	—	5	*17*
Kwangtung	—	—	—	—	—	—	—	—	—	1	—	—	1	1	1	3	1	7	9	*24*
Kwangsi	—	—	—	—	—	—	—	—	—	1	—	—	—	—	1	1	1	—	3	*6*
Yunnan	—	—	—	—	—	—	—	—	—	—	—	—	—	—	3	12	4	2	4	*25*
Kweichow	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	5	*5*
Fengtien	—	—	—	—	—	—	—	—	—	—	—	—	—	3	—	2	—	—	17	*22*
Kirin	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	9	*10*
Helungkiang	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2	3	*5*
Sinkiang	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	*1*
Mongolia	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	1	*2*
Kokonor	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
All China	4	18	15	5	18	10	13	31	24	36	41	56	43	57	24	43	67	72	81	*658*

*See reference to Table III.

above, there are others which must be taken into consideration. The droughts and floods recorded are not equal in intensity; and there is wide difference in the extent of area affected, sometimes the whole of China, at others only a few districts. The apparent increase in the number of droughts and floods from ancient to modern times is due to the fact that we have more records of recent happenings. Because of the ease of communication droughts and floods in places within a short distance from the capital of the empire easily attract attention, while calamities of the same or greater intensity occurring in distant provinces often escape notice. Tables I and II show that practically in every dynasty except the Ming the number of droughts and floods of the metropolitan province exceeds that of any other. Factors other than decrease or increase of precipitation may favor or check the occurrence of droughts and floods. It is well known to the Chinese historians that during the Yen Dynasty the Mongol invaders demolished the drainage system in the Yellow River valley, and consequently at that period both droughts and floods were particularly numerous in the provinces along the Yellow River.

The factors mentioned should, however, affect the number of droughts and floods alike. If there is a rapid rise in the number of droughts accompanied by a sudden drop in the number of floods at the same time, a drier climate is probably indicated; and, conversely, a marked decrease in the number of droughts followed by an equally marked increase in the number of floods means a moister climate.

With this as a criterion we note several points in Tables III and IV. The data before the Christian era are too scanty to be utilizable. During the fourth century the number of droughts greatly exceeds those of the preceding or the following centuries and is accompanied by very few occurrences of flood. A less marked but similar condition prevailed in the seventh century. In the twelfth century and again in the eighteenth there is a marked decrease in the number of droughts together with an equally marked increase in the number of floods. In the fifteenth century there were very few cases of floods, while droughts were quite frequent. If we divide the total number of droughts of each century by the total number of floods during the same interval, we have the ratios appearing in Table V. The data for the seventeenth century and later have not been computed, for, as has been already remarked, the method of enumeration is not the same as in the preceding periods.

In a recent bulletin published by the U. S. Department of Labor Ta Chen has found that Chinese migration can be grouped into three periods: those of the seventh, fifteenth, and nineteenth centuries.[2] During the first period Chinese migrated to the Pescadores and For-

[2] Ta Chen: Chinese Migrations, With Special Reference to Labor Conditions, *Bull. U. S. Bur. of Labor Statistics No. 340*, Washington, 1923, p. 4. Noted in the *Geogr. Rev.*, Vol. 15, 1925, pp. 144–145.

mosa; in the second period, to Malaysia; and in the third, about 1860, the third oversea migration started with destinations in Hawaii, North America, and South Africa. Mr. Chen found that the most significant causes of emigration are pressure of population and droughts and famines; while during the last century Chinese emigration was much accelerated by the ease of communication and by the demand for labor to open up new lands. Such, however, cannot be said of the seventh or fifteenth century. Mr. Chen has tabulated the number of droughts that occurred in four provinces of China, where the overseas laborers are usually recruited (Chihli, Shantung, Fukien, and Kwangtung), from 1369 to 1596, without however being able to point out that droughts were especially numerous in the fifteenth century.

TABLE V—RATIO OF DROUGHTS TO FLOODS BY CENTURIES

PERIOD	RATIO	REMARKS
A. D.		
100–200	1.98	
200–300	1.60	
300–400	8.20	Dry
400–500	2.06	
500–600	4.10	Dry
600–700	3.30	Dry
700–800	1.32	
800–900	1.80	
900–1000	1.80	
1000–1100	1.70	
1100–1200	1.04	Wet
1200–1300	1.80	
1300–1400	1.05	Wet
1400–1500	2.25	Dry
1500–1600	1.95	

SEVERE WINTERS

With regard to temperature it is possible to follow one of the methods Brückner used in his "Klimaschwankungen," i. e. tabulation of the number of severe winters. There are three chapters in Tu Shu Tsi Cheng entirely devoted to the records of severe frost, great colds, and the like, observed in Chinese history. In Table VI the years with severe frost and great cold have been tabulated for the period 500–1600 A. D. along with those given by Brückner[3] and by C. E. P. Brooks[4] for Europe in the same period.

[3] Eduard Brückner: Klimaschwankungen seit 1700 nebst Bemerkungen über die Klimaschwankungen der Diluvialzeit, *Geogr. Abhandl. herausg. von A. Penck*, Vol. 4, No. 2, Vienna and Olmütz, 1890, p. 268.

[4] C. E. P. Brooks: The Evolution of Climate, London, 1922, p. 155.

Considering the divergent sources from which the data were obtained, the number of severe winters in China and in Europe agrees remarkably well, particularly in showing that the fifteenth century was relatively mild while the period 1100–1400 was comparatively cool. In the last column of Table VI the number of years in which sun spots were observed in China has been added. The sun-spot records are taken from Tu Shu Tsi Cheng and from the standard histories of different dynasties.[5] As is well known, the curve of sun-spot

TABLE VI—NUMBER OF SEVERE WINTERS IN EUROPE AND CHINA

PERIODS	CHINA	EUROPE	SUN-SPOT YEARS (CHINA)
500–600	19		7
600–700	11		0
700–800	9		0
800–900	19	11	8
900–1000	11	11	1
1000–1100	16	16	3
1100–1200	24	25	16
1200–1300	25	26	6
1300–1400	35	24	9
1400–1500	10	20	0
1500–1600	14	24	2

numbers and that of earth temperature follow each other in a general way in the sense that the temperature is lower at sun-spot maxima. The Chinese of these early days had no telescopes, but the occurrence of large sun spots observable by the naked eye is some indication of the intensity of solar activity. It is therefore interesting to find in Table VI that the number of years with records of sun spots increases as the number of severe winters increases.

LATE FROSTS AND SNOWFALLS

Another indication of temperature conditions in past times is obtained from the dates of frost and snowfall. Now the Chinese calendar fixed the date of the first frost in autumn as October 24, which is probably the mean date of the first frost in the Yellow River valley 2000 years ago. To be comparable with recent data the old records must be exact as to the date of occurrence and location and numerous enough to make certain that the case is not an exception. Also the phenomena must have occurred in a region from which we have records today.

[5] See also Alexander Hosie: Sunspots and Sun-shadows Observed in China, B. C. 28–A. D. 1617. *Journ. North China Branch of the Royal Asiatic Soc.*, Vol. 12, 1877, pp. 91–95.

Fortunately in the history of the South Sung Dynasty (1127–1279) there were forty records of spring snowfall in the capital (Hangchow) with the exact date in the Chinese calendar.[6] The first record was entered in the year 1131, and the last in 1264. According to the meteorological records made during the ten years 1905–1914 in Hangchow, the mean date of the last snowfall in spring during that period was found to be February 23, and the latest date March 15. Of the 40 records of spring snowfall registered in the South Sung Dynasty all

TABLE VII—LATEST SPRING SNOWFALL OBSERVED IN HANGCHOW BY DECADES

DECADE	DATE	DECADE	DATE
1131–1140	April 11	1211–1220	March 30
1141–1150	April 19	1221–1230	May 15
1151–1160	April 13	1231–1240	May 16
1161–1170	April 19	1241–1250	March 8
1171–1180	March 26	1251–1260	April 11
1181–1190	March 26		
1191–1200	April 2	Mean	April 9
1201–1210	March 9	1905–1914	March 15

save two came later than February 23, while there were twenty of them that came later than March 15.

If we take the 39 records made in the period of 130 years from 1131 to 1260 and divide them into 13 groups, each consisting of the records of a decade, it will be seen that the latest date of spring snowfall in each decade occurred later than March 15 with the exception of the periods 1211–1220 and 1241–1250, as shown in Table VII.

The recent snowfall observation in Hangchow covers only a period of ten years, which is too short. According, however, to the observation made at Zi-ka-wei Observatory near Shanghai about a hundred miles northeast for the thirty years 1873–1902, the latest date for the last snowfall in spring during that period was found to be April 4 (1882)[7], which is early compared with the snowfall records in Hangchow during the twelfth and thirteenth centuries. As Shanghai is north of Hangchow by a degree of latitude and is more than one degree Centigrade colder in mean annual temperature, it would seem safe to assume that the latest date of spring snowfall in Hangchow for the last three decades of the nineteenth century was still earlier. This occurrence of snow in Hangchow in the late spring during the twelfth and thirteenth centuries would suggest a severer climate and thus

[6] The Chinese calendar was first transformed into the Julian calendar by the aid of Pierre Hoang's "Concordance des chronologies Néoménique chinoise et européenne" (Shanghai, 1910), and seven days were added to each in order to make comparable with the Gregorian calendar.

[7] J. de Moidrey: Notes on the Climate of Shanghai 1873–1902, Shanghai, 1904, p. 31.

confirms the conclusion we have drawn from a comparison of the severe winters.

The snowstorms in Hangchow and in the lower Yangtze valley as a whole are usually caused by a certain type of weather, a well-developed anticyclone in Siberia and a low center passing south of the Yangtze valley approaching the Eastern Sea. The wind backs from southeast to northeast and then to northwest, accompanied by a considerable drop in temperature. Practically all of the winter precipitation of the lower Yangtze valley is derived under this type of pressure distribution, although the amount is not heavy when compared with that obtained from the summer showers. On the other hand, if the Siberian anticyclone is weak or has disappeared, the depression, if there is any, will pass north of the Yangtze valley. The wind will then veer from southeast to southwest and then to northwest. It may cause a dust storm (although never so severe in the Yangtze valley as in North China), but no rain or snow is produced; the drop in temperature, while usually noticeable, will not be so large as in the former case.

According to the investigation of C. J. Kullmer, "when sun-spots are few in number cyclonic storms move in a great variety of tracks, but when spots are numerous the storms tend to confine themselves to a few well-defined tracks, so that storminess is more or less restricted to certain areas within which it is highly concentrated."[8] Since according to records of Chinese history during the twelfth and thirteenth centuries the sun spots observed were particularly abundant, we should expect a concentration of storm tracks. If they should take place in the southern part of the Yangtze valley it would have the effect of making the lower Yangtze valley cool and damp. In this connection it may be noted that, according to Table IV, during the twelfth and thirteenth centuries the floods in the lower Yangtze provinces were especially numerous—indeed, there were more floods then than in any other century except in the Manchu Dynasty—while the provinces along the Yellow River were almost exempt from them.

[8] Ellsworth Huntington: The Climatic Factor, *Carnegie Instn. Publ. No. 192*, Washington, 1914, p. 253, note.

A DOT MAP OF THE DISTRIBUTION OF POPULATION IN JAPAN*

Wesley Coulter
University of Chicago

[With separate map, Pl. IV, facing p. 284]

THE cartogram showing distribution of population by political divisions has obvious limitations: seldom is distribution uniform even for small areas. A method of approaching nearer the actual facts is attempted in the accompanying population map of Japan.

The symbols used are circles and dots. The former represent the larger cities, 69 of which are distinguished.[1] The area of the circles is proportional to the size of the cities, which range from 28,685 to 2,050,126. The population of these 69 cities subtracted from the total for the provinces[2] leaves a remainder distributed in smaller cities, towns, and rural districts and here shown by dots. Each dot represents 10,000 persons, the scale being one-fourth that for the circles.

In connection with the placing of the dots there were used (1) a hachured relief map on a scale of 1:1,200,000 which showed, in addition to topography, the location of cities and towns; (2) the topographic map of the Imperial Geological Survey of Japan on a scale of 1:1,000,000, showing, in addition to topography, the location of "cities, towns, small towns, villages, and hamlets"; (3) 280 topographic maps of the Imperial Geological Survey of Japan on scales varying from 1:20,000 to 1:200,000, showing, in addition to topography, the use of the land in great detail; and (4) a sketch map for the province of Hokkaido, showing the distribution of cultivated land on the island in 1914.[3] These maps, together with numerous photographs and the relevant literature available, afforded helpful clues as to the detailed distribution of population.

The map reflects the relation of the distribution and density of population to relief. The thickly populated plains stand out in sharp contrast to the sparsely peopled mountains. The Kwanto Plain, on the island of Honshiu, with about six million people, is

*Acknowledgment is made of suggestions by Wellington D. Jones, Professor of Geography, University of Chicago, as to the making of the accompanying map.

[1] Statistical data were obtained from "État de la population de l'empire du Japon au 31 Décembre, 1913," Tokyo, 1916.

[2] The map does not include the Kurile Islands, the Riu-Kiu Islands, nor the Bonin Islands, which together form three of the 86 provinces of Japan.

[3] Wellington D. Jones: Hokkaido, the Northland of Japan, *Geogr. Rev.*, Vol. 11, 1921, pp. 16–30.

the largest area of dense population in Japan. The Mino-Owari Plain and the Kinai Plain, on the same island, also are densely populated. On the island of Shikoku, the plain in Sanuki province in the north may be identified by its large number of dots. In Kiushiu, the larger areas of dense population are on the plains in the northern and northwestern parts of the island. All the plains referred to are characterized by intensive agriculture. Many small agricultural villages are scattered over them. On many parts of them two crops are raised each year, rice during the summer and wheat and barley during the winter. Near the larger cities of the plains market gardening is carried on, and there three crops a year are produced. The density of the agricultural population of Japan is suggested by the fact that, on the average, the cultivated land per family is less than three acres.

The sparse population of the mountainous regions as compared with that of the plains may be illustrated by noting that, whereas the province of Hida in central Honshiu has a population of only 34 per square kilometer, Mushashi, on the Kwanto Plain, has 649 per square kilometer. The general decrease in density of population towards the northern part of Japan is effectively shown. In Hokkaido much tillable land still is forested; the cultivated area per family there is seven and one-half acres.

Thirty-five cities of Japan have a population of more than 50,000, and thirty-four range from 24,102 to 47,295. Tokyo, the largest city, has more than 2,000,000 inhabitants. The larger cities are on the larger plains which face the Pacific Ocean. Tokyo, Yokohama, and Yokosuka are on the Kwanto Plain; Nagoya is on the Mino-Owari Plain; and Kobe, Osaka, and Kyoto are on the Kinai Plain. These cities on the east-central coast of Honshiu lead in manufactures and commerce. The localization of the urban population is strikingly exhibited by the map.

Geographical Review Vol. XVI, No 2 1926 Plate IV

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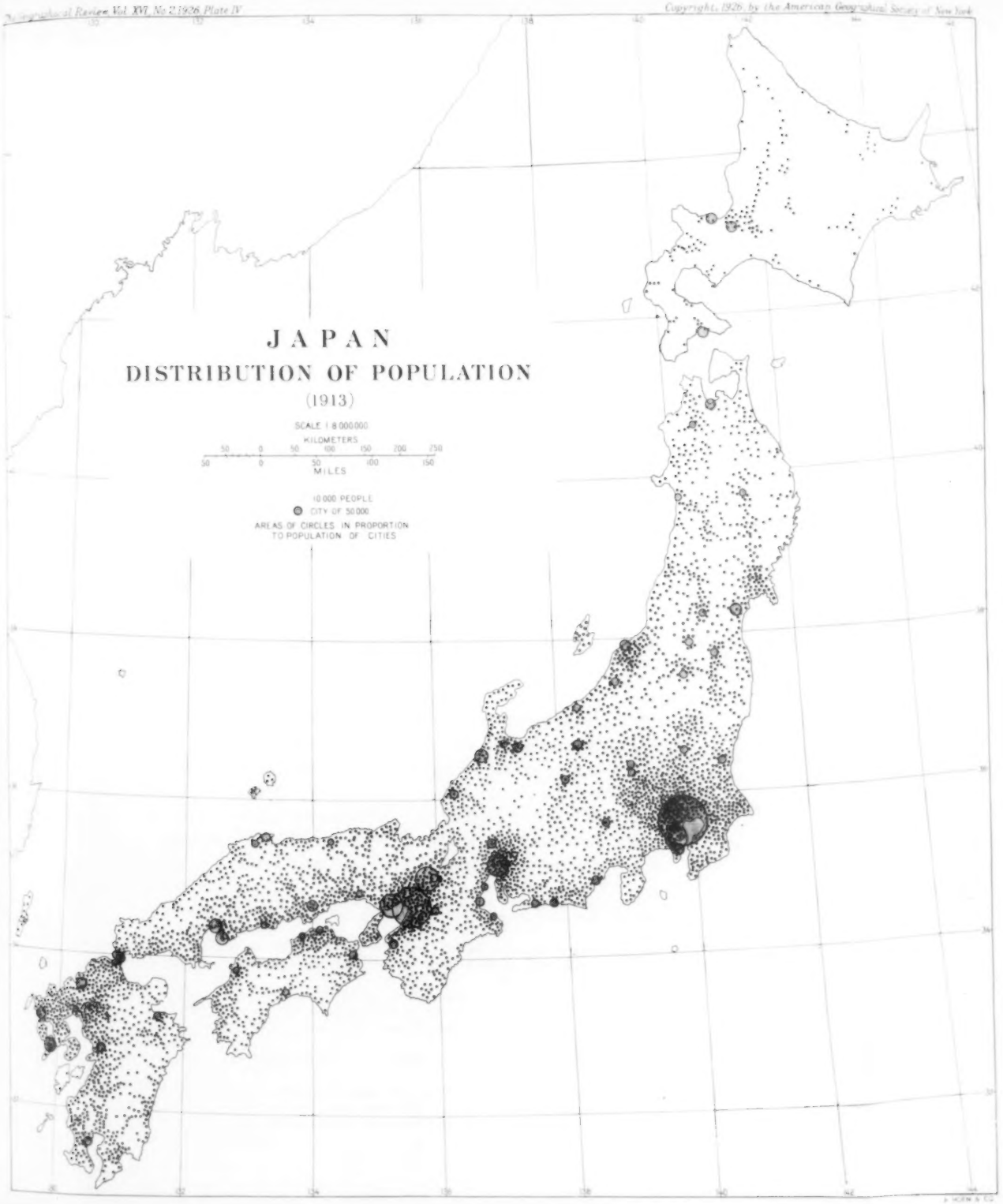


A NEW MAP OF WORLD RAINFALL*

Mark Jefferson
State Normal College, Ypsilanti

RAINFALL probably conditions man's use of the earth quite as much as any element in his environment. Topography, except in its broad features of flat country and rough country, has much less effect than is usually supposed.

How, then, is the rainfall distributed over the earth? What map shall we consult in 1926? Not Herbertson's map of 1898 nor Bartholomew's "Atlas of Meteorology" of 1899, for since then the annual precipitations of Europe and Africa have been worked up as wholes and the delineation for North and South America greatly improved in detail. Reger worked over the European data in 1903,[1] and Kincer those for Africa in 1923.[2] For North America there is Kincer's admirable map of annual rainfall in the United States in the Department of Agriculture's "Atlas of American Agriculture," of 1917; Moctezuma's rainfall map of Mexico published in 1924[3]; and the rainfall of Alaska by the U. S. Weather Bureau for 1925,[4] to which R. F. Stupart, the distinguished director of the Canadian Meteorological Service, has kindly added a manuscript map with the results of Canadian observations, 1925.

South American Rainfall

For South America we have so much new knowledge that the simple drawing of the older maps—probably the best example in the world of the simplicity of ignorance—has given place to something of the complexity of nature.

South American rainfall was worked over in 1907 by Dr. Voss,[5] but he had very meager data. Since then the number of stations where rain is measured has been multiplied many times in the Argentine,[6] in Chile,[7] and in Brazil.[8]

*Figures 13 and 14 from Mark Jefferson: Principles of Geography, Harcourt, Brace & Co., New York, 1926.

[1] Joseph Reger: Regenkarte von Europa, *Petermanns Mitt.*, Vol. 49, 1903, pp. 11–13.

[2] H. L. Shantz and C. F. Marbut: The Vegetation and Soils of Africa, New York, 1923, pp. 245–246.

[3] Atlas termopluviométrico de la República Mexicana, Tacubaya, 1924. The maps are based on observations for 1906–1910 except in a few instances where observations from 1920 to date were used.

[4] R. C. Mize: Climatological Data, Alaska Section, Jan.–Dec., 1924, U. S. Weather Bureau, Washington, 1925, 1926.

[5] E. L. Voss: Die Niederschlagsverhältnisse von Südamerika, *Petermanns Mitt. Ergänzungsheft No. 157*, 1907.

[6] W. G. Davis: Climate of the Argentine Republic, Buenos Aires, 1902, 1910.

[7] Mark Jefferson: The Rainfall of Chile, *Amer. Geogr. Soc. Research Ser. No. 7*, 1921.

[8] Brazilian government work summarized in Mark Jefferson: New Rainfall Maps of Brazil, *Geogr. Rev.*, Vol. 14, 1924, pp. 127–135.

I insert the two maps of Figure 2 (p. 288) to make clear the advance in complexity that comes of our increase in knowledge. In Chile the modern map puts dry valleys—regions of irrigation—between rainy mountain ranges, just as any traveler sees them; though Voss's map reversed the picture and showed in the latitude of Valparaiso

FIG. 1—A new map of world rainfall: western hemisphere. The grades of rainfall distinguished are excessive (over 80 inches), black; abundant (40 to 80 inches), ruled; sufficient (20 to 40 inches), dotted; scanty (under 20 inches), blank. Annual rainfall includes melted snow.

a wet valley between dry hills. In Brazil the new map shows excessive rain on the coast and on the eastern flank of the Andes and develops the details of the singularly dry region, the province of Ceará, near the eastern corner of the republic, which was foreshadowed or hinted at by the smooth ovals of Voss's map. The conditions here are now known with some accuracy through the extensive observations of the Brazilian government, which gathered the facts as a preliminary measure in remedying some of the ills of this region of drought. In the Argentine there has been less change, as the topography is of

simpler pattern and a good beginning of observations had been made at an earlier date. The data for these three countries are now sufficient to supply a reasonable outline of the distribution of rainfall, which we have not previously possessed, so that the present map supersedes all older ones for that part of the continent. As to northern and

FIG. 1—A new map of world rainfall: eastern hemisphere. The bands of small circles off some shores show upwelling cool water which contributes to desert aridity. The two parts of Figure 1 are reproductions on a smaller scale of Figures 13 and 14 in the author's "Principles of Geography."

northwestern South America we have still very scanty knowledge. The true isohyetals for Colombia, Venezuela, and the interior of the Guianas must have great complexities.

As a geographer's use of rainfall calls for knowledge of the position of certain critical values among isohyetals rather than for knowledge of all the gradations of rainfall, I limit myself in drawing these maps to the scanty, sufficient, abundant, and excessive rainfall, separated at 20, 40, and 80 inches, which are roughly 500, 1000, and 2000 millimeters.

Arid Coasts with Upwelling Water

Interest should attach to the representation of upwelling waters off desert coasts, where they are prevalent. This is done on the maps by lines of contiguous little circles; and, where less constant, by circles more widely separated, as off the coasts of California and the eastern United States. I have taken their position from Söderlund's excellent

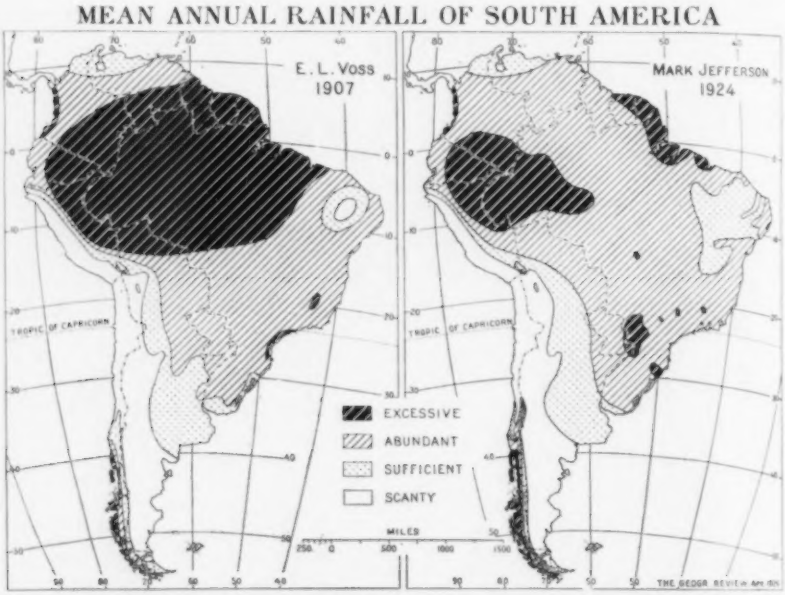


Fig. 2—The mean annual rainfall of South America, maps of 1907 (Voss) and 1924 (Jefferson). Four grades of rainfall are distinguished: excessive, over 80 inches; abundant, 40 to 80 inches; sufficient, 20 to 40 inches; scanty, under 20 inches.

"Svensk Skolatlas" but have corrected them by Schott's "Physikalische Geographie der Atlantischen Ozean" and the Atlas of the Pacific by the Deutsche Seewarte in Hamburg. Söderlund makes the upwelling on the Peruvian coast occur only to the south of Lima and shows it in West Africa overlapping regions of excessive rain, which does not and apparently cannot occur. Along the Peruvian and north Chilean coast upwelling water is cold, and it is known as the Humboldt Current from the island of Mocha as far north as the Gulf of Guayaquil. Where it occurs the coast is well-nigh rainless. One might associate the coldness of the water with the aridity.

This is especially pertinent at the present time because in 1925 there occurred coincidently a failure of the cold current and the falling of heavy rain in the desert.[9] A common way of describing the phenom-

[9] R. C. Murphy: Oceanic and Climatic Phenomena Along the West Coast of South America During 1925, *Geogr. Rev.*, Vol. 16, 1926, pp. 26–54.

enon is to say that the northward-flowing Humboldt Current disappeared and a warm, southward-flowing stream, *El Niño*, took its place. At any rate, with warm water alongshore instead of the usual cool water, a notoriously arid coast was deluged by rain.

In explaining the aridity of coasts with upwelling water there are, of course, two elements to be distinguished—the absence of prevalent onshore winds and the inability of cool air to supply rain. If the winds are strongly onshore there can be no upwelling water; but there will be rather its opposite, an undertow of water returning seaward below the surface from the water accumulated at the shore by the wind. Here the air that brushed the surface water landward will become cooled by ascent if the coast is high and give up abundant rain. Water wells up from cold depths only to take the place of surface water when it is brushed away by offshore winds. On the beaches of the Great Lakes the water is found too cold for bathing when the wind is off the land.

The offshore wind of the Peruvian current is to be looked for in the southeast trades that blow steadily to westward 50 or 100 miles away from the coast.

As to the second element, the inability of cool air to supply rain, there cannot be much evaporation from the cool water or in the cool air that overlies it; if in the afternoon the land becomes hot enough to attract a sea breeze, the land must warm the cool air that blows against it enough to neutralize the adiabatic cooling produced by ascent to a considerable height. That is, air at 65° may be warmed 25° by the land it is blown against if the ground has only the moderate temperature of 90°. It would take an ascent of nearly 5000 feet to cool the air by that 25°, leaving it nearly a mile in the air at the same temperature with which it started and with no progress made toward the condensation of water vapor. Almost the only onshore winds of the coast have this cause—the afternoon heating of the land; and the land is doubtless always hotter than 90° when the sea breeze sets in. The conditions are therefore very unfavorable to rainfall.

On monsoon coasts, like those of Colombia or Nigeria, the wind blows constantly toward a warm land, there is an undertow, and the surface water is warm; there is much evaporation, and the warm moist air on ascending the mountain slopes is cooled to its dew point adiabatically with resulting heavy precipitation.

An Adequate Rainfall Map of the World

An adequate rainfall map of the world calls for the coöperation of all meteorological services in the world. Observations should be contemporaneous. Ten years would give an excellent idea of distri-

bution of the rain in space. If the years 1930 to 1939 could be used for the observations there would be time enough before they began for an international committee headed by a man like Dr. Hellman to study the problem and make arrangements for observers in critical regions. Even without additional expense for extra stations, such a coöperation might accomplish more than all the work of the last century.

OCEAN TRADE ROUTES

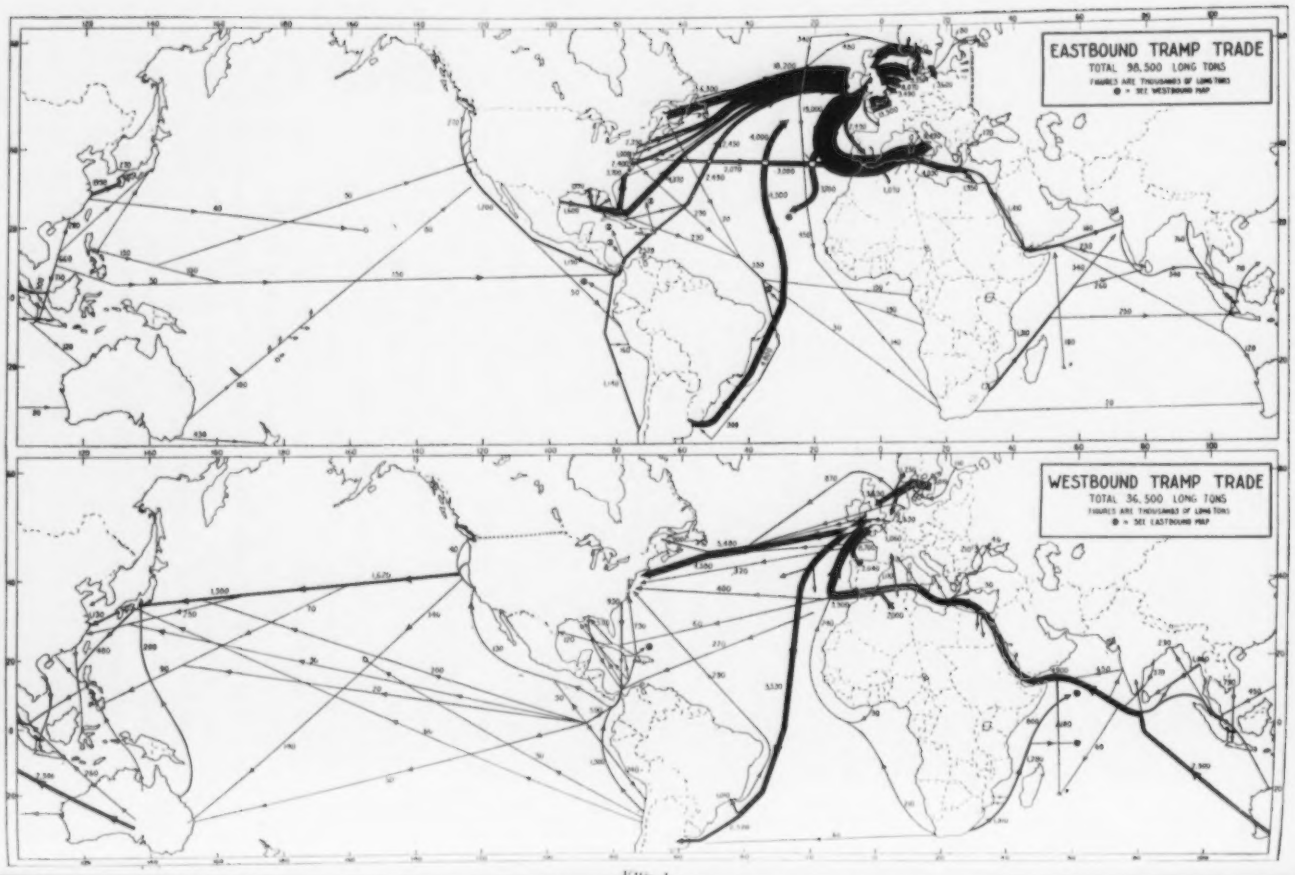
E. S. Gregg

U. S. Department of Commerce

THE statement that half of the shipping of the world is engaged regularly in the North Atlantic is received by most people with frank incredulity; yet in truth it is not far from the facts, as is shown by recent studies of the U. S. Department of Commerce. A map showing tracks for full-powered steam vessels is often interpreted as indicating the relative importance of the ocean trade routes of the world, and such maps are nearly always given in commercial geographies and books on shipping. The density of traffic over the main ocean tracks is something usually guessed at.

A ship plying regularly between scheduled foreign ports is called a "liner" by the general public and by Kipling felicitously a "lady." In equally picturesque phraseology the drab general-cargo vessel has come to be known as a "tramp." The ocean-borne trade of the world is carried in these two kinds of vessels. Liners ply between terminals almost as regularly as railroad trains. Tramps, in contrast, have no fixed routes or regular sailing schedules. They go from port to port wherever cargo offers. The demand for ship tonnage varies because of the seasonal nature of crops and the needs of commerce. Steamships in liner trades are operated by their corporate owners; tramp ships are operated by their owners or, most frequently, are offered for hire to anyone who desires to move a shipload of cargo at one time. The distinction between the tramp ship and the liner is chiefly in regularity of employment. Structurally each type merges into the other with respect both to speed and size. The liner furnishes service in times both of prosperity and depression. The tramp ship serves two general public purposes. It acts as a regulator of ocean freight rates at times and places where the demand for transportation exceeds the facilities offered by liners. It is the drudge of the seas, carrying the dirty and cumbersome cargoes which have great weight or bulk in proportion to value.

The total weight of the ocean-borne cargoes carried in the world's foreign and colonial trades has never been exactly stated, because so many articles and standards enter into the computation and because the methods and periods, on which the returns of governments are based, vary. A committee of the British Board of Trade in 1916–1917, after careful computations, estimated that the total volume of the world's sea-borne commerce in 1912 "probably amounted to between


EASTBOUND TRAMP TRADE
TOTAL 98,500 LONG TONS
FIGURES ARE THOUSANDS OF LONG TONS
● = SEE WESTBOUND MAP
WESTBOUND TRAMP TRADE
TOTAL 36,500 LONG TONS
FIGURES ARE THOUSANDS OF LONG TONS
● = SEE EASTBOUND MAP

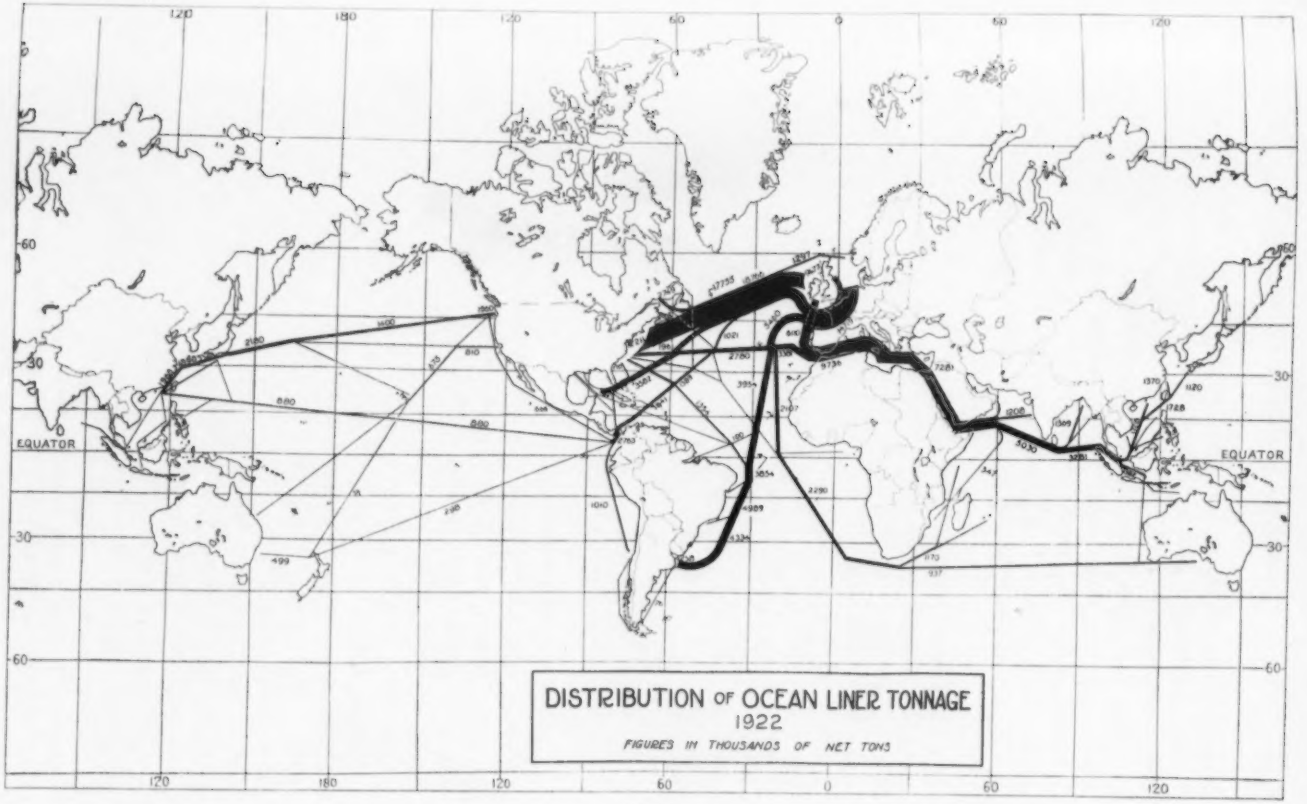

120
180
120
60
0
60
120
60
30
EQUATOR
30
60
DISTRIBUTION OF OCEAN LINER TONNAGE
1922
FIGURES IN THOUSANDS OF NET TONS
EQUATOR
30
60

FIG. 2

250,000,000 and 300,000,000 tons, of which more than half appears to have originated in the British Empire, the figures being swollen by the large export of coal from the United Kingdom."

The two accompanying charts of Figure 1, show graphically the results of a study of the ocean trades in which tramp ships play a leading rôle. The thirteen commodities listed in Table I were taken as the basis of tramp ship employment; the second column gives the tonnage of these articles exported from all countries in 1922.

TABLE I—MOVEMENT OF TRAMP SHIP COMMODITIES IN 1922

COMMODITY	LONG TONS	COMMODITY	LONG TONS
Coal	71,450,000	Rice	3,560,000
Ore	14,690,000	Cotton	2,110,000
Wheat	14,580,000	Wood Pulp	1,740,000
Wood	9,020,000	Rye	1,320,000
Sugar	7,120,000	Oats	1,030,000
Corn	5,790,000	Barley	860,000
Fertilizer	4,150,000		
		Total	137,420,000

These thirteen commodities do not, of course, exhaust the list of cargoes carried by tramps, nor are these thirteen carried wholly by tramps. Clays and earths, stone, sulphur, and copra among raw materials, and beans, linseed, cottonseed, and other oil grains afford them frequent cargoes but do not approach in volume the articles tabulated. On the other hand, grain and other cereals, especially wheat and rice, are carried in large quantities by liners, as are cotton, lumber, and sugar. But the season enters into the transportation of these articles, and, even when they are carried in liners, the tramp ship materially affects freight rates. These and other variations partly offset one another and do not change the estimate of 137,500,000 tons as the maximum limit of the ocean-carrying trade within which tramp ships operated in 1922.

The determination of the liner routes of the world is in many ways more difficult than the determination of the tramp ship trades. Since liners carry miscellaneous package cargo, it is impossible even to estimate the weight of such articles. The only feasible way to find out the relative importance of the different liner routes is to determine the cargo capacity offered by liners on these routes. The capacity offered, of course, is practically always in excess of the cargo carried, as liners frequently must sail only partly loaded.

Tramp ships were considered to outnumber liners before the war. The popular idea was that two-thirds of the ships of the world were

tramps and only one-third liners. The idea was incorrect, but tramp ships made up at least between 30 and 40 per cent of the tonnage of the world. A post-war study recently completed shows a remarkable change. Today at least 80 per cent of the shipping space for the carriage of cargo is offered by liners. Table II and Figure 2 give the facts in sufficient form.

TABLE II—CLEARANCES OF SHIPS WITH CARGO, 1922
(*In Thousands of Net Tons*)

ROUTE	TOTAL	LINERS	PER CENT LINERS
N. America to Europe	25,832	20,796	80
N. America to S. America	2,016	1,709	85
N. America to S. Africa	294	208	72
N. America to Australia	845	652	77
N. America to Asia via Panama and Suez Canals	1,390	1,205	94
N. America Pacific Coast to Asia	2,852	2,139	75
Europe to Asia (Suez Canal)	6,384	6,107	95
Europe to S. and W. Africa	1,926	1,519	80
Europe to Australia	2,060	1,802	87
Europe to S. America	5,918	4,379	74
	49,517	40,516	82

The most striking thing about the charts is the overwhelming concentration of tramp and liner shipping in the North Atlantic. Over 46 per cent of the liner space offered to shippers in 1922 was in this area, and fortuitously 46 per cent of the tramp ship commodities, including the North Sea and Baltic, were also in this region. An equally striking feature is the comparative unimportance of shipping in the Pacific. Contrary to the general notion, more shipping is engaged in the trade with South America than in the transpacific trades. Some of the economic and geographic reasons for the distribution of shipping over the routes of the world were formulated in a previous article in the *Geographical Review*,[1] wherein it was pointed out that a country liberally endowed by nature with raw materials necessary to an advanced industrial development finds exploitation of these resources more profitable than shipping ventures.

[1] E. S. Gregg: The Influence of Geographic Factors on Ocean Shipping, *Geogr. Rev.*, Vol. 12, 1922, pp. 424–430.

AN ABRUPT CHANGE OF DEPTH IN THE SULU SEA

F. H. Hardy
U. S. Coast and Geodetic Survey

NOTWITHSTANDING announcements that appear from time to time in the popular press and even in technical journals, there is, in fact, little authentic evidence of marked changes in the ocean bottom not due to silting or similar action. Changes in the contour of the floor and in depth are always taking place where the bottom material is susceptible of displacement by the action of waves and ocean currents and where rivers and tidal streams deposit silt in coastal water, scour, build up, and sift this material continuously or intermittently. Such changes, while comparatively slow when considered year by year, may, after years of continued action in the same direction, cause profound changes in the shallow coastal waters. However, it is not the purpose of this article to discuss changes of this nature but rather changes which appear to have been caused by crustal movement, either sudden or gradual. What evidence have we of such changes?

The United States Coast and Geodetic Survey has been surveying and charting the coastal waters of our territory for more than a hundred years and is the only organization that has made systematic and careful surveys of these waters. From time to time areas where changes have been reported as affecting navigational charts have been resurveyed, and within the last ten years the Bureau has been engaged in a resurvey of the entire Atlantic and Pacific coasts of the United States in greater detail and by methods and with appliances far more precise than were available when the earlier surveys were made. The later surveys have been compared with the earlier for the purpose of noting what changes, if any, have taken place. Not until all records of both surveys have been studied by expert cartographers and hydrographers can evidence of changes be accepted. It is known that depth measurements were not taken with the same precision in the earlier surveys, and until very recently it has not been possible to fix accurately the geographical position of soundings when beyond the range of visibility of shore objects.

So seldom has the critical examination of two or more surveys of the same water area under the jurisdiction of the United States revealed changes that could not be accounted for by silting or by the action of waves or ocean currents or be dismissed as probable evidence of in-

accuracy in the earlier survey that any such case is worthy of special note.

In an area in the waters of the Philippine Islands where radical changes in depth would not be expected to occur, two carefully executed surveys show conclusively that a deepening of over 140 feet

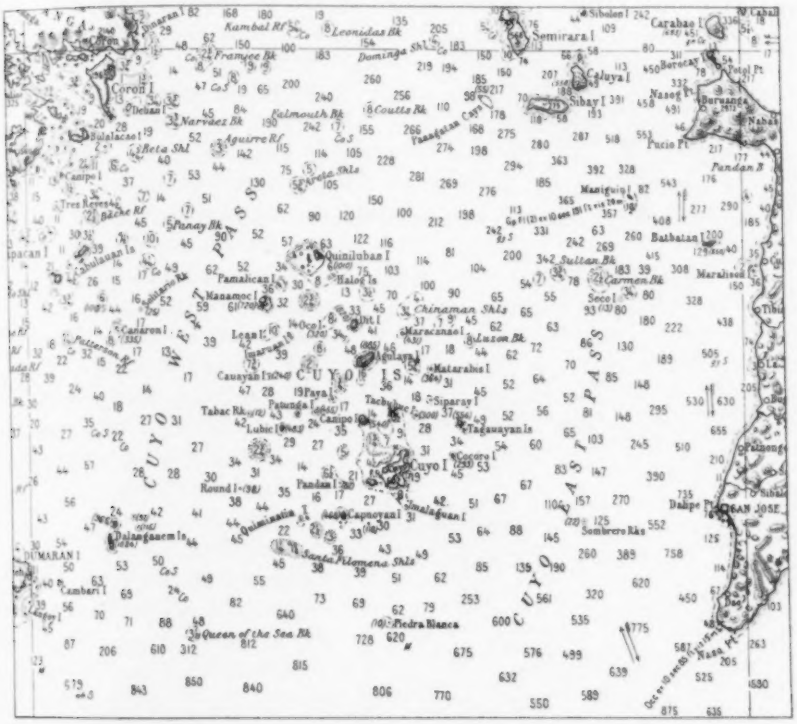


FIG. 1—Reproduction on a reduced scale of a portion of U. S. Coast and Geodetic Survey Chart No. 4200. The cross marks the area shown in Figure 2.

occurred between the date of the first survey and that of the second. The interval between the surveys was 26 months.

On October 2 and 3, 1914, a hydrographic survey was made of a shoal in the northern part of the Sulu Sea about 60 miles west of the Island of Panay and six miles north of Cuyo Island. On December 18, 1916, this shoal was resurveyed.

Both surveys were executed by modern methods. In the first survey, depths were obtained by use of the hand lead; in the second, either by hand lead, pressure tubes, or direct wire measurements. No doubt exists of the accuracy of any of the soundings. The position of the soundings of both surveys was determined by the usual three-point method, the objects angled on being accurately located

either by triangulation or the plane-table. The same objects were used in both surveys.

The general location of the shoal is shown by the cross on Figure 1, which is a copy of a section of U. S. Coast and Geodetic Survey Chart No. 4200.

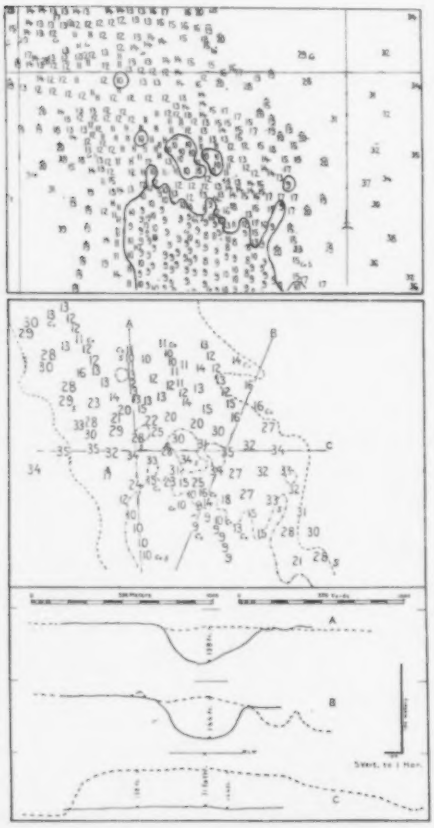


FIG. 2—The upper plan shows soundings of survey of October, 1914: the lower plan the resurvey of December, 1916. Depths are in fathoms. Profiles are shown in sections A, B, and C.

The results of the first survey, October, 1914, are shown in the upper plan of Figure 2, the depth unit being fathoms and all depths of ten fathoms or less being enclosed by curves. The Chief of Party executing this work, in referring in his report to one of the detached ten-fathom spots says: "The bottom is sand and coral and shows green. The coral apparently is small, no large heads being visible." The soundings were taken quite close together, the spacing between them being approximately 75 yards.

The Chief of Party making the second survey was working under instructions to search for a reported rock and to complete the examination of certain other shoals in this general locality. It was not intended to make a resurvey of this shoal, as the careful development made in the first survey was considered adequate. While proceeding from one locality to another and sounding over this shoal, the surveyor noticed the discrepancy between the soundings obtained and those shown by the previous work and so continued the resurvey, extending it until a substantial agreement with the previous survey, both to the north and the south, was obtained. The results appear in the lower plan of Figure 2.

The depth curves determined by the first survey are superimposed upon the plan of the second survey, and the figures represent the depth in fathoms determined by the second survey. The dot-and-dash lines represent the ten-fathom curves determined by the first survey, namely

all depths determined by the first survey between these curves were ten fathoms or less. All depths obtained on the first survey between the curves made by a series of dashes were twenty fathoms or less. Below the plans are shown three sections, A, B, and C. The profile of the bottom for each of these sections determined by the first survey is shown in dash lines; that of the same section determined by the second survey in full lines. The vertical scale of these profiles is five times that of the horizontal. The plane of mean low water is shown for each profile by a short line at the edge of the figure. As will be noted, the greatest change in the profile of the bottom of section A is 138 feet and of section B 144 feet. The most uniform increase in depth is shown by the profile of the bottom of section C, where the second survey showed a fairly uniform increase of about 140 feet in depth over that determined by the original survey.

Another shoal partially surveyed in 1914 two or three miles south and west of this was surveyed in 1916, but no changes in depth were found; and all other work done in this vicinity in 1916 agreed with the previous work. This would indicate that the changes in depth were local rather than general.

No attempt will be made here to explain these changes. It is interesting, however, to note that in March, 1915, the occurrence of an earthquake in this general vicinity was detected.

AMERICAN GEOGRAPHICAL SOCIETY

Meetings of January and February and Elections to Fellowship. The annual meeting of the American Geographical Society was held on January 26, at the Engineering Societies' Building, 29 West Thirty-ninth Street. After the reading of the annual reports and the election of officers for 1926, the presentation of the Charles P. Daly Gold Medal was made to Captain Robert A. Bartlett, who then addressed the Society on "Hair-Seal Hunting Off the Newfoundland and Labrador Coasts." The lecture was illustrated with moving and still pictures of great interest.

At the regular monthly meeting of February 23 an illustrated lecture was given by Mrs. Rosita Forbes, "From the Red Sea to the Blue Nile," based on her recent travels in Abyssinia.

At the January and February meetings of the Society, President Finley presiding, there were presented with the approval of the Council the names of 77 candidates who were duly elected as Fellows.

Annual Report of the Council

New York, January 21, 1926

To the Fellows of the Society:

Among the papers in the *Geographical Review* that have stimulated discussion and represent new field work and new ideas the following may be mentioned as especially noteworthy:

"Looking Back at Malthus," by Professor Mark Jefferson, discusses the trends of population growth and their relation to food supply.

"The Siberian Sea Road," by Commander N. A. Transehe, discusses the work of the Russian Hydrographical Expedition to the Arctic 1910–1915 and is illustrated with a map constructed from original and hitherto unpublished surveys.

"The Danish Ethnographic and Geographic Expedition to Arctic America: Preliminary Report of the Fifth Thule Expedition," by Dr. Knud Rasmussen, gives the first account in English of three years' work in the Arctic during which the expedition visited all the known Eskimo tribes and traversed the region between Greenland and Siberia.

"An Expedition to the Kalabit Country and Mt. Murud, Sarawak," by Dr. Eric Mjöberg, presents the results of a journey into the unexplored interior of Borneo.

Included in the numbers of the *Geographical Review* for 1925 are the results of original explorations and field surveys in northwestern Alaska, in the James Bay region, in the Amazon valley, in Java, in Greenland, in British Columbia, and in Bolivia. Each number of the *Geographical Review* presents from eight to ten contributions of the highest rank and offers to Fellows of the Society, to members of the Association of American Geographers, and to libraries an account of the world's principal advances in geographical knowledge. The material published in 1925 relates to almost every branch of the subject and includes 36 principal articles, 93 notes, and 84 reviews.

The books and maps published by the Society during the past year include the following:

1. Bering's Voyages: An Account of the Efforts of the Russians to Determine the Relation of Asia and America, by F. A. Golder. Vol. II, Translated and in part annotated by Leonard Stejneger.

This volume contains a translation of Steller's Journal of the sea voyage from Kamchatka to America and return on the Second Expedition, 1741–1742. Like Volume I, it contains a bibliography which consists of reference material relating to Steller within which is discussed also Steller's own publications, both those in manuscript form and those that have been published.

2. Of books announced in previous years three have been reprinted during 1925 on account of the continued demand for them by Fellows of the Society and others. They are: THE GEOGRAPHICAL LORE OF THE TIME OF THE CRUSADES, by John K. Wright; LEGENDARY ISLANDS OF THE ATLANTIC, by William H. Babcock; and DESERT TRAILS OF ATACAMA, by Isaiah Bowman.

3. Satisfactory progress has been made in the editing of a series of volumes on Arabian geography and history by Professor Alois Musil which embody many years' field work. The first volume has been set up in type, and the second volume prepared for the printer.

4. BIBLIOGRAPHIE GÉOGRAPHIQUE

The coöperative arrangement with the Association de Géographes Français and this Society continued with success during 1925 and resulted in the production of Volume 33, dealing with geographical publications for 1924. The volume has been printed and will be distributed early in 1926. The Society not only initiated the plan of coöperation but has at all times encouraged the extension of it. In accordance with the suggestion of Professor de Martonne, similar coöperation has been proposed to a number of other geographical societies with every promise of success. Following our example, the Royal Geographical Society gave its adhesion to the plan and will distribute the volume throughout the British Empire. It must be a matter of deep satisfaction to the geographers of all countries that this standard geographical bibliography has been advanced to a position of wide recognition and support, thus avoiding the costly duplication of bibliographic effort on the part of many societies.

5. Upon the MILLIONTH MAP OF HISPANIC AMERICA, on which the Society has been engaged the past four years and which has been made possible by the generous support of your Vice President, Mr. James B. Ford, there has been the same steady advance upon a broad front as noted in preceding reports. In addition to three published sheets there are fourteen sheets upon which the Society's work of compilation and fair drawing has been practically completed. Similar work to various stages has been done on a large number of other sheets. The quality of the work has been raised through the generous coöperation of a large number of institutions and companies who have placed at the Society's disposal original material of astonishing variety and unsuspected quantity. Especially noteworthy has been the coöperation of the governments of Ecuador and Panama, not only in the way of supplying material but in a financial way. No less hearty has been the continued coöperation of the governments of Peru, Bolivia, Chile, and Colombia.

6. In addition to its assistance in supplying material for the millionth sheet for Panama, the government of Panama has coöperated with the Society in producing a new map of the Republic on the scale of 1:500,000, photolithographed and printed from the Society's fair drawings prepared for the millionth sheets, with suitable extensions to cover the whole of the Republic. Through the help of the school inspectors, engineers, hacendados, merchants, and military forces, an immense amount of new data was obtained. The map has been distributed among the principal public schools of the Republic and all the important government offices.

Mention may also be made of the map of Tacna-Arica prepared for the Plebiscite and Boundary commissions appointed by President Coolidge. The map was engraved and printed by the U. S. Geological Survey from parts of the fair drawings of the La Paz sheet of the Millionth Map of Hispanic America in course of publication by the Society.

7. In the *Geographical Review* a number of especially noteworthy maps have been published to which special reference may be made at this place.

a. Three maps of Alaska were published in color to illustrate "The Value of Alaska," by the late Alfred H. Brooks. They relate to the land classification, fisheries, transportation, water power, and mineral deposits and represent information obtained by various government bureaus for many years past.

b. With the regrouping of the peoples of Central Europe as a result of the several treaties of peace, new geographic and economic relationships came into being. One of a series of papers which the Society has published in the *Geographical Review* is "The Kingdom of the Serbs, Croats, and Slovenes," by Borivoje Ž. Milojević of the University of Belgrade, and the paper is illustrated by four colored maps showing geographical regions, density of population, religions, and languages of Yugoslavia.

c. From many sources, including principally his own notes and diaries, Commander Transehe has been able to construct a map of the Siberian seacoast showing the results of the important discoveries made by the Russian Hydrographical Expedition to the Arctic. The map is on the scale of 1:8,500,000 and shows the entire coast line from Alaska to the White Sea, with bathymetric contours and spot depths. It is the first map upon which the detailed position and relations of Nicholas II Land are shown authoritatively.

d. Accompanying Dr. Rasmussen's paper described in the first paragraph of this report is an important map entitled "Preliminary Map of the Territories mapped by the Fifth Thule Expedition." It gives many details of Cockburn Land, Melville Peninsula, and Southampton Island not hitherto shown upon the maps.

e. "Flood Plain Belts of the Inner Amazon Basin" by C. F. Marbut and C. B. Manifold, shows the low country of the Amazon Valley intimately related to the principal settlements and the future development of Amazonia. The map is in part the result of coöperation between the U. S. Department of Agriculture and the Society during Dr. Marbut's journey to Brazil in 1924.

f. In addition to the colored insert maps mentioned above are a number of black-and-white maps that represent original contributions to knowledge. Among these may be mentioned

i. The geological sketch map accompanying Dr. Rasmussen's report and giving the geological constitution of the coast-line areas in Boothia Peninsula, Cockburn Land and its associated land masses, Melville Peninsula, Southampton Island, and Fox Land.

ii. A series of maps showing distributions of economic importance in the geography of Java.

iii. An original topographic sketch map of the Mt. Logan region, Gaspé Peninsula, by J. F. Collins, illustrating a paper in coöperation with M. L. Fernald.

THE SCHOOL OF SURVEYING

During the past year the Society's School of Surveying has given short courses in field astronomy and geographical surveying to seven persons. Of these one has since been to Alaska, one has become topographer on an oil prospecting expedition, and three are about to undertake extensive surveying operations in opening up a hitherto unexplored region. Another is at present in the neighborhood of Siam doing reconnaissance survey work. Mr. Lincoln Ellsworth, before attempting the flight to the North Pole with Amundsen last May, took a short course in field astronomy in its relation to aerial navigation in the polar regions. In addition, various persons have applied to the School for technical information and advice in respect to surveying matters. Captain George H. Wilkins, leader of the Detroit Arctic Expedition shortly to embark from Point Barrow on an exploring expedition by airplane in the Arctic, has approved the methods suggested to him by the School

for position finding and navigating in the polar regions. All the navigating data which he will use, such as sun azimuth tables (embodying a new method), charts, and forms have been prepared by the staff of the School.

A special study has been made of the possibilities of aerial surveying, a branch of work which promises greatly to alter if not to revolutionize the practice of topographical mapping. A complete set of astronomical computation forms has been compiled to further the work of finding geographical position by astronomical means and the use of wireless telegraphy. Other experimental work undertaken by the School has been the testing of new types of aneroid barometer and the elimination of the difficulty of sticking paper onto plane-table boards when in the field. The latter has resulted in the construction of a new type of plane-table board which so far appears to be entirely satisfactory.

Thanks to the generosity of Dr. Alexander Hamilton Rice, a Vice President of the Society, the School is now equipped with a very comprehensive collection of surveying instruments. These include four micrometer theodolites, a prismatic astrolabe, wireless equipment, the latest types of mercurial and aneroid barometers, plane-table outfits, telescopic alidades, and a large collection of watches and half chronometers. Many of these latter are valuable Ditisheims, Mardins, Leroys, and other makes which have received absolutely first-class certificates of performance. The School also has an extensive library of technical surveying literature.

Following the Society's practice of sending representatives to important scientific gatherings and occasions of special geographical interest, a delegate of the Society attended the joint session of the American Historical Association and the History of Science Society at Ann Arbor, Mich., December 29, 1925, and the meeting of the Association of American Geographers at Madison, Wis., December 30 and 31, 1925, and January 1, 1926. The Society is also represented in the National Research Council, Division of Geology and Geography, and its committees on Pioneer Belts and Problems of Human Migration. It has a representative on a committee on the delimitation of geographic regions (in North America) of the Association of American Geographers. Special mention should be made here of the South American mission of Mr. Raye R. Platt, head of the Department of Hispanic-American research. He was able to establish relations with government bureaus and scientific institutions interested in topographic survey work; to give them reliable information on the new Map of Hispanic America on the scale of 1:1,000,000 on which the Society is engaged; and to examine the collections of original surveys in their archives in order to complete the collection of source material already assembled in the files of the Society. Mr. Platt visited eight of the South American republics and was most cordially received everywhere. The Society's collection of the sheets of all the various systematic surveys in the countries visited has been brought completely up to date, and a great deal of original compilation material of various sorts, such as railway and road surveys, airplane surveys, river traverses, travelers' route maps, and areal surveys made by commercial firms for the commercial exploitation of natural resources, has been secured. An approximate summation of the unpublished data collected in 1925 gives the following: area covered by accurate topographic surveys, 51,000 square miles; by less accurate surveys, 32,500 square miles; by traverses of various types, 8198 miles. The Society's collection of original surveys in Hispanic America is probably unsurpassed, and the relations now established with government bureaus and scientific institutions in South America will afford a means of keeping in constant touch with new survey work.

During 1925 the Society awarded eight gold medals, as follows:

Charles P. Daly Medal

Dr. Knud Rasmussen, leader of successive Thule expeditions and author of the report mentioned in an earlier paragraph. (*Geogr. Rev.*, Vol. 15, 1925, pp. 521–562.)

Captain Robert A. Bartlett, Commander of the *Roosevelt* and the *Karluk* and of the Third Crocker Land Relief Expedition. (*Geogr. Rev.*, Vol. 16, 1926, p. 134.)

Brigadier General David L. Brainard, member of the Lady Franklin Bay Expedition, 1881–1884. (*Geogr. Rev.*, Vol. 16, 1926, p. 134.)

Cullum Geographical Medal

Pedro C. Sanchez, Director of the Central Mexican Bureau of Geography and Climatology. (*Geogr. Rev.*, Vol. 16, 1926, p. 134.)

Harvey C. Hayes, Research Physicist of the U. S. Navy and inventor of the Sonic Depth Finder. (*Geogr. Rev.*, Vol. 16, 1926, p. 134.)

Lucien Gallois, Professor of Geography at the University of Paris, collaborator and editor of the *Annales de Géographie* and President of the Association de Géographes Français. (*Geogr. Rev.*, Vol. 16, 1926, p. 134.)

David Livingstone Centenary Medal

Luis Riso Patrón, Director of the Oficina de Límites of Chile and head of the first Chilean Commission to make a precise survey of the Cordillera of the Andes. (*Geogr. Rev.*, Vol. 16, 1926, p. 133.)

Erich von Drygalski, of the University of Munich, leader of the Greenland Expedition of the Berlin Geographical Society (1891–1893) and of the German Antarctic Expedition (1900–1903). The latter award is dated 1926. (*Geogr. Rev.*, Vol. 16, 1926, pp. 133–134.)

The Society has endorsed and aided the Arctic expedition of Captain George H. Wilkins. The generous support of the Detroit Aviation Society has made it possible to advance the plans rapidly, and it is proposed to make a flight from Point Barrow, Alaska, late in March. Captain Wilkins will attempt to reach the Pole of Relative Inaccessibility (*Geogr. Rev.*, Vol. 10, 1920, pp. 168–169) and to determine the presence or absence of land in the large unexplored portion of the Arctic basin north of Alaska. In a similar way the Society has endorsed and aided the plans of Dr. Vilhjalmur Stefansson for field work in Greenland and Labrador, including an investigation of early Norse voyages. Meteorological instruments have been sent to Trujillo, Peru, where a voluntary weather station will be maintained by Major Otto Holstein, a Fellow of the Society. The recent change of ocean currents off the coast of Peru gives the locality special climatic significance. A member of the staff spent six months on leave in Alaska working upon the map collections of the Alaska Road Commission in continuation of the work on the general map of Alaska described in preceding reports.

Additions to the library during the year comprise 1117 books, 567 pamphlets, 7473 new issues of periodicals, 2591 maps, and 49 atlases. The collection now numbers 83,410 volumes of books and bound periodicals, 9658 pamphlets, 65,403 maps, and 1322 atlases. Among conspicuous gifts to the library from friends of the Society have been the following:

1. Monographic reports of De Filippi's Asiatic expedition and Transactions of the World Power Conference, from James B. Ford, Esq.
2. Books and periodicals to the number of 1061 volumes, from the Hispanic Society of America.
3. Photographs of Jamaica, Cuba, and Central America, from Henry B. Thayer, Esq., of Boston.

The lectures of the Society are attended by an increasing number of Fellows. The speakers and titles for the past year are as follows: Mr. Merian C. Cooper, "The Migrations of the Bakhtiari"; Dr. Philip S. Smith, "Exploring in Northern Alaska"; "The Epic of Mt. Everest," with an introduction by President Finley; Mr. Archer Butler Hulbert, "The Oregon Trail"; Dr. Alexander Hamilton Rice, "The River Branco-Uraricuera-Parima"; Dr. C. U. Clark, "Spaniard and Moor."

The number of Fellows at the close of the year was 4569, of whom 397 are Life Fellows. In addition there are 6 Honorary Members and 38 Corresponding Members.

The Report of the Treasurer submitted herewith gives a condensed balance sheet and a summary of the income and expenses of the Society.

PHILIP W. HENRY
Chairman

REPORT OF THE TREASURER FOR 1925

Receipts and Expenses

During the year there have been received from annual dues, interest on investments, and sales of publications	$70,590.49
There have been expended for salaries, house expenses, library, meetings, publications, postage, insurance, etc.	87,979.03
Balance charged against Special Deposit Fund	$17,388.54

Condensed Balance Sheet, December 31, 1925

Cash	$15,732.53
Sundry balances and investments	96,100.00
Inventory of publications	13,121.30
	$124,953.83
Capital Account, Balance uninvested	$937.30
Annual dues paid in advance	4,607.93
Special Fund for general purposes	63,173.91
Sundry deposits and reserves	26,765.28
Millionth Map Publication Fund, Balance	29,469.41
	$124,953.83

REPORT OF THE SPECIAL COMMITTEE

New York, January 21, 1926

The Committee appointed at the meeting of the Council held on December 17, 1925, to nominate officers for the vacancies to occur in the Council in January, 1926, beg to nominate the following named gentlemen for the offices designated and move that the same be approved and presented to the Society for election at its meeting to be held on January 26, 1926:

		Term to expire in
President	John H. Finley	January, 1927
Vice President	Philip W. Henry	January, 1929
Domestic Corres. Secretary	W. Redmond Cross	January, 1929
Treasurer	Henry Parish	January, 1927
Councilors	Madison Grant John Greenough Roland L. Redmond Franklin D. Roosevelt Paul Tuckerman	January, 1929

H. Stuart Hotchkiss
W. Redmond Cross
Hamilton Fish Kean
Committee

Presentation of the Charles P. Daly Medal to Captain Robert A. Bartlett. The Charles P. Daly Medal for 1925 was presented to Captain Robert A. Bartlett at the January meeting of the Society, following the announcement of the award in the January number of the *Geographical Review* (p. 134). In presenting the medal, President Finley spoke as follows:

"Before I proceed to present the Charles P. Daly Medal, as authorized and directed by the Council of the Society, I feel that I must first give, by way of preface, philosophic basis for making such distinctions in a democracy.

"It was the special prerogative of Kings and Emperors in the monarchical centuries to bestow distinction of their whim or design. Romance has found material for its pages in the royal favor shown persons who had made brave and high adventure and their elevation to unusual honors and public notice. Democracies, while nominally discountenancing all such distinctions as setting one man above another, have nevertheless a lingering liking for the markings of distinction. It is of significance that in democracies there are developing agencies of one sort or another for recognizing outstanding service to humanity, particularly in the field of science and exploration, where so many men who have made the greatest contribution to human progress in the past have gone to their graves not only unhonored and unsung but even in penury and want.

"The Nobel Institute in Norway is one such agency; dedicated to searching out men and women, in any and every part of the world, who in science or letters or in the promotion of better human relations are deemed to be doing the most for the race, and inscribing their names upon its immortal roll. The honorarium which accompanies the honor is so generous as to relieve the recipients of anxiety about food and shelter, at any rate. A number of such awarding organizations have recently been established in America. Their awards carry no heraldic insignia and no such honoraria, but they acquaint the public with services that should be appreciated while the man or woman who has given them is still alive.

"This medal which I am about to present looks in that direction and should be helpful to democracy in giving recognition to real merit and service and in emphasizing the fact that individual 'kudos' is not inconsistent with the rule of the demos. It is a hopeful indication and prophecy and not a mere social survival such as are the distinctions that depend upon political influence or royal favor.

"As to Captain Robert Bartlett, to whom the award is made, he was born in Newfoundland and went to a Methodist college there. He passed the examinations which entitled him to the title Master of British Ships, and he had the degree Master of Arts from Bowdoin College, which graduated Longfellow and Hawthorne a hundred years ago, but he is a Master of Arts which they never knew. If I were still a university president, I should be ready to confer upon him a degree, as I did a few years ago upon that great godlike figure, Cardinal Mercier—which degree would also be represented by the letters LL.D. but meaning, in the case of Captain Bartlett, Doctor of Latitude and Longitude. As it is, I have only a medal to add to his already ample collection. But we beg him to add one more, the Charles P. Daly Medal for 1925, in recognition of the fact that, though his polar exploits lie back of the war which has obliterated so many memories, his heroic ventures are not forgotten. Especially do we remember his loyal, self-effacing trail-breaking service to the man whom he helped to the Pole, Commander Peary, whom we also remember in recognizing his chief aid.

"I once presided at a supper sitting between the discoverers of the two poles—functioning as the equator. Tonight I think of myself as standing as the figure of Atlas (as I have found him pictured in an old geography), not bending beneath the weight of the universe but erect at the North Pole, looking down over the whirling sphere, and finding no one living more worthy to receive this recognition than you, Captain Robert Bartlett, upon whom I have now the honor of bestowing this medal."

In accepting the medal, Captain Bartlett said:

"When a man receives a medal he is told as you, sir, have done so gracefully, why he receives it. But inside of a man another voice speaks. It tells him of some moment greater than all others of his life. That voice speaks to me tonight. It tells me of an afternoon in April, 1909, when I stood with the greatest Arctic Commander that ever lived, at latitude 87° 47′ North, and looked toward the Pole then almost within reach. Under excellent conditions of ice and weather this man, strong, honest, went forward. I had had the honor of helping him—that is what this medal means to me."

Recent Publications

The Lesser Antilles. *Map of Hispanic America Publication No. 2* is "The Lesser Antilles" by Professor W. M. Davis. The introduction gives the general geography of the islands. It presents very briefly the origin of the inhabitants, their difficult economic problems, and their eventful history. The main part of the text is almost exclusively physiographic in nature. As a result of extensive field work Professor Davis is able to describe the various topographic features and particularly the coastal features in terms of a systematic sequence of island development. He discusses the climatic classification of islands, the peculiar aspects of island development in the marginal belts of coral seas, stable and unstable volcanic islands, and the various complexities of island form as different agencies are combined in shaping them. He then applies these considerations to specific islands of the Lesser Antilles, one by one.

To illustrate the discussion there are included sixteen full-page photographs and 23 black-and-white reproductions of Hydrographic Office and Admiralty charts which give details of coastal outline, topography, and sea floor. There are also 43 pen sketches showing critical details of coastal physiography from place to place. In the Society's Millionth Map of Hispanic America two sheets, Lesser Antilles—North and Lesser Antilles—South, include all of the islands mentioned in the text. The book closes with two suggestive sections on the biological relations of the islands and a comparison of Atlantic and Pacific coral reefs. The whole forms one of the most important analytical pieces of work which Professor Davis has ever done and is a fitting introduction to the larger problem of coral reefs in general, on which Professor Davis will publish through the Society a still more substantial memoir next year.

Practical Hints to Scientific Travellers. This is a series of guides under the editorship of Dr. H. A. Brouwer, professor of geology at the Technical University of Delft. By arrangement with the publishers, Martinus Nijhoff of the Hague, the volumes are distributed to American readers by the American Geographical Society. The volumes deal with less well known parts of the world, of prime interest to the scientific explorer in various fields. They aim to provide the traveler with that practical knowledge which is the basis of all successful expeditions, "with information as to the things of every day life as well as to the customs and manners which prevail among white and colored peoples in distant regions." Each region is treated by an authority. There is no attempt to conform to a rigid scheme: the subject in each instance is developed so as to bring the most important matters into the foreground. At the same time many of the "hints" will be found applicable elsewhere. Volume I includes: Practical Hints to Explorers in the Netherland-East Indies by H. A. Brouwer and N. Wing Easton; Notes on Travel in South- and East-Africa by P. A. Wagner and T. G. Trevor; Hints to Explorers and Prospectors Covering Travel in the Philippines by Warren D. Smith; Volume II, Travelling in Polar Regions by W. Werenskiold; Hints to Explorers in Spitsbergen by A. Hoel; Hints to Ex-

plorers in Novaya Zemlya by O. Holtedahl; Hints to Travellers in Greenland by O. B. Böggild; Practical Hints to Explorers in Turkestan by D. Mushketov; Volume III, Notes on Travelling in Mexico by J. A. A. Mekel; Renseignements pratiques sur l'Indo-Chine, spécialment le Tonkin, à l'usage du voyageur naturaliste, by E. Patte; Notes on Touring and Camping in India and Burma by H. Walker; Hints to Travellers in New Zealand by P. Marshall; Practical Hints to Scientific Explorers in New Guinea by E. R. Stanley; Conseils pour un voyage scientifique au Maroc by G. Lecointre. The volumes are illustrated by maps, diagrams, and photographs.

The "Bibliographie Géographique" for 1924. The twenty-fourth volume of the annual *Bibliographie Géographique* is now ready for distribution in the United States and Canada by the American Geographical Society. In accordance with an arrangement concluded in 1924 between the Society and the Association de Géographes Français, the Society participates in the publication of this famous bibliography which covers the geographical literature of the world. The volume for 1923 was placed on sale in this country early in 1925. In the volume here announced the publishers have had the coöperation of the Comitato Geografico Nazionale Italiano and of the Royal Geographical Society of London following the example of our Society. One result of this broadening of international coöperation in the enterprise has been the increase in the number of items included, 2300 major items in the volume for 1924 as against 1936 in that for 1923. Most of the items relating to North America and many relating to South America have been contributed by members of the staff of the American Geographical Society.

Map of the Republic of Panama, 1:500,000 [7.89 miles to 1 inch]. The Society has published for Señor Sabas A. Villegas of Panama City, acting for the government of Panama, a new map of the republic which has been approved and accepted as the official map of Panama. The map is printed from the original compilations prepared for the Map of Hispanic America on the millionth scale on which the Society is now engaged. More than 100 original surveys, many of them unpublished, were incorporated into the compilation, and the map is of the highest degree of accuracy possible in a map of Panama at the present time. In general the map follows the scheme of the International Map of the World on the scale of 1:1,000,000. Rivers are shown as surveyed and unsurveyed and contours as surveyed and approximate by solid and broken lines, but the hypsometric tints have been omitted and the provinces of the republic shown in colors instead. The map is in Spanish throughout, including title and legend.

GEOGRAPHICAL RECORD

NORTH AMERICA

The High Mountains of Colorado. In the United States, exclusive of Alaska, there are sixty-one named mountains that exceed fourteen thousand feet in altitude. Of this number, Colorado has forty-seven, California thirteen, and Washington one. Two-thirds of these mountains are scattered along or near the Continental Divide; others are in the Sangre de Cristo range; and Pikes Peak, in the Front Range, towers above Colorado Springs.

The history of exploration in Colorado is reflected in the naming of these fourteen-thousand-foot peaks. In the Front Range, first entered by explorers and scientists, the names of Gray and Torrey, famous for their contributions to Colorado flora; of Long and Pike, well-known explorers; and of Bierstadt, the painter, are all attached to peaks of fourteen thousand feet or higher. Politicians, particularly those who supported "free silver," were in favor with the miners and, in consequence, we find the tallest peaks in the mining districts named for such figures as W. L. Stewart, a senator from Nevada, and others. The mountains Harvard, Princeton, Yale, and Columbia, popularly known as the Collegiate Peaks, were named by an exploring party largely made up of college men. And finally the Spanish names of the southern peaks recall the fact that this region was early discovered and settled by Spaniards from the Southwest.

Facts as to the surveys, naming, and ascents of the fourteen-thousand-foot peaks of Colorado are discussed in a booklet, "Fourteen Thousand Feet, a History of the Naming and Early Ascents of the High Colorado Peaks," by John Lathrop Jerome Hart (Supplement to *Trail and Timberline*, June, 1925; published by the Colorado Mountain Club, Denver, 1925). The footnotes in this work form an excellent bibliography on the maps, mountain surveys, and mountain climbing of Colorado.

Land Settlement in the Great Lakes States. The northern portion of the three Great Lakes States, Minnesota, Wisconsin, and Michigan, is a region in which land settlement has been as active since 1900 as anywhere in the United States. An explanation of the late development of this region may be found largely in the existing conditions of timber, climate, accessibility, and in the quality of the land. Because this territory is characterized primarily by a coniferous growth, often cut over, the task of clearing the land is difficult and expensive. The region, in addition to being too far north for corn or dependable silage, has a long winter feeding season and a real frost hazard. There are pockets of good land scattered throughout, but a large proportion of it is too rocky, sandy, swampy, or rough for profitable cultivation. The sand areas are particularly bad. (See the note "Land Waste in Michigan," *Geogr. Rev.*, Vol. 15, 1925, pp. 478–479.) Furthermore, the railway lines are of the poorest, and water transportation is largely potential.

The method of developing the northern part of these three states is very different from that employed when the southern portion of the same states was settled. The days of free land and homesteading are past, and the settlers' success has become dependent to a certain extent upon the policies and practices of the land companies. A large part of this land was originally acquired by lumber companies, which, having logged it, are now anxious to dispose of it. Land settlement or real estate companies have attempted to colonize portions of it with varying degrees of success. Because clearing is a slow process and because the type of farming best suited to local con-

ditions does not admit of rapid returns, many of the land colonization schemes are paternalistic. In some cases this has had the result of making the farmer too dependent or, when the company is not particular as to the type of purchaser, of introducing incompetents. To attract progressive people, improvements such as roads and schools must be offered. Some development companies, trying to unload their land quickly, become unscrupulous, and hardships follow for the settlers.

In order to minimize the number of failures and to consider carefully the welfare of the settlers, the United States Bureau of Land Economics has coöperated with the Agricultural Extension Station of the University of Minnesota in a study of the problem published in "Land Settlement and Colonization in the Great Lakes States" (*U. S. Dept. of Agric. Bull. No. 1295*, Washington, 1925). This involves a careful examination of the methods of various typical land companies and ends with recommendations for the control of the situation in the best interests of the settler.

The Chaparral and Desert Vegetation of California. California is a region of unusual interest to the plant geographer. The geological past has bequeathed to it a wide variety of vegetations which are maintained in their diversity in the present age by a bold topography and the resultant contrasting climates. Three recent ecological papers dealing with California are of broad geographical importance.

LeRoy Abrams in an article on "The Origin and Geographical Affinities of the Flora of California" (*Ecology*, Vol. 6, 1925, pp. 1–6) shows that California is not only a meeting ground of two distinct types of flora closely related to the floras of other parts of North America, but that there has developed an endemic flora typical of California itself. In the higher mountains no less than "75 per cent of the genera . . . are common to North America and Eurasia." On the other hand, investigations carried out by Abrams demonstrated that in the Californian deserts 80 per cent of the trees and shrubs were "either restricted to America or had tropical affinities, while only 12 per cent belonged to the Northern Extratropical Flora." The flora typical of California, however, is neither that of the high mountains nor of the deserts. It is, rather, the flora of the valleys and foothills west of the Sierra Nevada divide. Here, though representatives are found of both of the extraneous elements, the vegetation is mainly characterized by "the presence of a large number of endemic genera, of genera especially rich in species," a fact that may be explained by the persistence of oceanic rather than continental climatic conditions ever since the Cretaceous period. The *Sequoia* and *Tumion*, relics of an earlier age, have thus been able to persist, whereas the climatic changes of the Tertiary long ago destroyed similar forms in other less tranquil parts of the world. Abrams adds that "the antiquity of the [Californian] flora is also seen in its affinities with southern Asia, the Mediterranean region, and the antipodes."

These Mediterranean affinities are well exemplified in the "broad-sclerophyll" plant communities. These communities in California consist of two formations: broad-sclerophyll forest and chaparral—the latter being the familiar scrub of the Californian hills, the counterpart of the *maquis* (or *macchie*), or *garigue* of Mediterranean lands. A detailed ecological study of these communities by William S. Cooper has recently appeared (The Broad-Sclerophyll Vegetation of California: An Ecological Study of the Chaparral and Its Related Communities, *Carnegie Instn. Publ. No. 319*, Washington, 1922).

The broad-sclerophyll forest formation is composed largely of oaks and live oaks. Its range corresponds to that of the chaparral with which it alternates in discontinuous patches from southern Oregon into Lower California. As a general rule, "as we go northward, or upward, we find the [sclerophyll] forest increasing in importance" relatively to the chaparral "until it comes into competition with a coniferous element, to which it soon becomes subsidiary."

Cooper divides the chaparral formation into two associations. The climax chaparral association is composed of a fairly large number of species of shrub and varies from place to place in its component elements, the most important species being *Adenostoma fasciculatum* (chamise or greasewood). This association dominates the higher mountains and coast ranges of southern California and northern Lower California. The conifer forest chaparral association, due mainly to forest fires, is found "in the middle altitudes of the Sierras, with extensive colonies throughout the higher mountains of northern California and Oregon, the north coast ranges and the mountains of southern California." The chaparral is of no great use to man except in so far as it retains water and prevents excessive erosion on steep slopes.

The range of the broad-sclerophyll communities as a whole is determined by climatic conditions: primarily by rainfall and to a far lesser degree by temperature. "The area with 10 to 30 inches of rainfall is the region of broad-sclerophyll dominance." In this respect, however, even more important than the quantity of rainfall is its distribution through the year. Cooper has drawn a map of western North America showing the percentage of the total mean annual precipitation that falls between April 1 and September 30. The greater part of California receives between 10 and 20 per cent during these months; a small area including Los Angeles and the region immediately to the northwest receives less than 10 per cent; and the southeastern and northeastern borders of the state receive more than 20 per cent. As one goes eastward, the percentage of summer rain rises until in the longitude of Denver and Cheyenne the iso-line for 70 per cent is reached. On comparing this rainfall map with Cooper's map showing the distribution of broad-sclerophyll species, "a remarkable correspondence will be at once evident between the region where the summer precipitation is less than 20 per cent and the region where broad-sclerophyll species are numerous. Moreover, the area of less than 10 per cent summer precipitation corresponds closely with the center of distribution of the sclerophylls."

The vegetation of the deserts of California is similarly governed primarily by the seasonal character of the rainfall. Forrest Shreve devotes an article to this subject (Ecological Aspects of the Deserts of California, *Ecology*, Vol. 6, 1925, pp. 93–103). The deserts lie to the east of the Cuyamaca, San Bernardino, and Sierra Nevada Mountains, which in winter cause the precipitation of moisture borne on the westerly winds from the Pacific. The influence of the winter rains is felt to a limited extent immediately along the western fringe of the Mohave and Colorado deserts, where the vegetation—relatively speaking—is abundant, varied, and closely correlated with the topography. Farther to the east the vegetation rapidly becomes sparser, more uniform, and more monotonous, until finally a broad barrier of extreme aridity is reached about midway between the mountains and the Colorado River. Beyond this barrier the desert vegetation is of quite a different nature, and in Arizona plant growth seems much more favored. Shreve observes that "it would be difficult to find anyone—at least in California—who would attribute this [latter] circumstance to any superior properties in the Arizona climate. The explanation lies, however, in the increasing amount of rain that falls within the growing season" (i. e. during the summer months).

Shreve asserts that "in order to appreciate the aridity of a desert we must not rely upon totals of rainfall and monthly averages, for the character of the vegetation is determined by the extremes rather than by the means." This fact, upon which modern students of desert conditions are tending to lay more emphasis, is of absolutely fundamental importance in relation to life in the desert, whether the life of plants, of animals, or of man.

SOUTH AMERICA

The Middle Basin of the São Francisco. In the *Annales de Géographie* for November, 1925, A. Mettler describes a landscape of the Brazilian plateau, a part of the

middle basin of the São Francisco in Minas Geraes. The region lies north of the great mining district of the state and is scantily populated. The characteristic tabular topography (compare the article "A Frontier Region in Brazil: Southwestern Maranhão" in this number of the *Review*) here presents a marked uniformity of aspect. The general plateau surface, *taboleiro*, with an elevation of over 1600 feet represents an old erosion surface, perhaps a peneplain. It is covered with a sort of brush, *cerrado*. Above rise the high plateaus, *chapadas*, sometimes improperly called *serras*, over 1900 feet. Their dry sandy soil supports a more open, scanty growth with fewer trees. The descent to the *taboleiro* is sharp and covered with *caatinga*, a true forest growth. The valley bottoms of the São Francisco and its tributary streams consist of a series of alluvial plains separated by rocky sills, corresponding to outcrops of hard sandstone, and inundated in time of flood. That of the master stream is 20 kilometers wide in places and in part is still unexplored.

On every hand are signs of the marked dry season, which normally lasts five months but may extend to nine. The herbaceous vegetation dries up, the trees shed their leaves, save those of the *matto*, the humid forest lining the watercourses. The salts concentrate in the alluvial lands and put difficulties in the way of cultivation, more particularly as regards irrigation.

As regards climate and soils the country could grow almost all kinds of tropical products. At present, however, it is divided into great *latifundia* largely given over to cattle raising. Crops are practically limited to local needs; this is true even of sugar cane and cotton. Improvement of communications especially with the sea, immigration, and irrigation are needed; and all these will require time.

The Good Roads Movement in Latin America. The frontier still stands close about the chief centers of population in most of the Latin-American countries: except in the Argentine Republic and Brazil there has been no pushing back on a broad front as in the United States. Encroachments on the frontier have taken place only in those areas, often widely separated, whose natural resources promised an early and large return for capital invested. In the greater number of cases difficult physiographic barriers separated these regions. Such conditions did not foster good roads in the days before the development of the motor vehicle when even the best means of road transportation were slow and expensive. The railroad, more adaptable than the highway to difficult physiographic conditions because of the possibility of construction on a very narrow gauge, best solved the transportation problem wherever the cost of construction was not out of all proportion to the benefits to be expected. Elsewhere the combination of pack train and river route was the best means of connecting with the market those regions whose products were still too limited to warrant the expense of building more efficient transportation lines. Even on the Argentine plains there was no great demand for good roads as long as the chief products were cattle, which could be driven to market, and hides, light in weight as compared with bulk. It was only when many of the ranches were given over to the raising of grain that the need of good roads was felt. The network of railroads extending out from Buenos Aires has partly filled this need; nevertheless, great losses are still experienced nearly every year because of the frequent impassability of roads between ranch and railroad. Until recently, however, the Argentine farmer thought that a good road must be a costly metaled road. The development of the construction and maintenance of good dirt roads is one of the greatest contributions made by the United States to the solution of the transportation problem in districts where the expense of metaled road construction is not justified. Practical demonstrations with American road-making machinery have proved to the Argentine farmer the adaptability of the well-constructed dirt road to his problem.

The great value of the good dirt road lies in the fact that its technique of construction has been so well worked out and the expense of construction is so low that it

can be undertaken as a community affair without Federal or state aid. Its limitations lie in the fact that it is well adapted only to the plain: in mountainous regions it cannot withstand the assaults of water erosion on steep slopes. If good roads are to be built, therefore, in the mountainous countries of Latin America they must be metaled roads. The cost of constructing these roads will have to be borne largely by the state or national governments. There comes a time in the life of every young and growing country when a large outlay of public or private funds is necessary and justified in order to provide transportation routes from areas of potential resources to a waiting market. It would seem that this time has come in most of the Latin-American countries. With motor transportation at its present high state of development it will be necessary in each case to decide whether the railroad or the motor road will best serve the need. In cases where the railroad is chosen no education of public sentiment is necessary. Much must still be done, however, in most of the Latin-American countries before the sentiment in favor of good roads is developed even to a point where the actual availability of funds is the only obstacle in the way of construction. There is, however, a growing appreciation of good roads in Latin America, and the good offices of the United States Department of Commerce have been largely instrumental in arousing it. At the Fifth International Conference of American States, at Santiago in 1923, a resolution was passed calling for a Pan-American conference on motor roads. In preparation for such a conference a committee representing the Transportation Division of the Bureau of Foreign and Domestic Commerce, the Bureau of Public Roads of the Department of Agriculture, and the Pan-American Union discussed the advisability of holding a preliminary conference of Latin-American engineers in the United States in order that they might study the highways of the United States in preparation for the work of the actual conference. The plan was presented by the Department of Commerce to representatives of the automobile industry and other industries interested in the development of good roads in Latin America, and as a result sufficient funds were contributed to defray the expenses of 37 Latin-American delegates to a conference in Washington and a tour of the highways of nine states during the summer of 1924 (see *Bull. Pan American Union*, Vol. 58, 1924, pp. 876–894). The official conference was held at Buenos Aires in October, 1925.

In "Motor Roads in Latin America," by Frank B. Curran (*U. S. Dept. of Commerce, Trade Promotion Ser. No. 18*, Washington, 1925), the reports on motor roads in Latin America prepared for the use of the preliminary conference at Washington have been published, and the volume presents for the first time a compilation of reliable information on the highway systems of the Latin-American countries. The statistical notes and the small-scale road maps contained in the text have to do with motor roads only, but a general summary of road conditions in each country is given as well as a discussion of construction problems and costs in different parts of the various countries, funds available, the attitude of government administrations, and public sentiment in road construction. The total length of good motor roads in all of Latin America is given as 8868 kilometers; 38,118 kilometers are passable for automobiles at all seasons, and 6230 kilometers are now under construction.

EUROPE

Human Habitations in the Massif des Baronnies. The Massif des Baronnies is a region of low mountains, well watered river valleys, and mild climate lying in the Prealps, or foothills of the French Alps, not far to the northeast of Avignon. The traveler in this hospitable *pays* will find perched on the hilltops and spurs of the mountains many a medieval village with its winding, narrow streets and three-storied houses. Not a few of these villages are half deserted. In some the upper tiers of dwellings, where there is danger of falling blocks of stone from the ruinous

château that overlooks them, have long since been left to decay. In others a few old folks linger on—at Turcs a solitary old man, at Curel an aged couple remain as the sole inhabitants. Still others are completely abandoned. Some of the people have left the district altogether; the majority, however, have moved to lower ground in the course of a gradual displacement that has been in progress intermittently since the fourteenth century (D. Mouralis: Les phénomènes d'habitat dans le massif des Baronnies (Préalpes du Sud), *Rev. de Géogr. Alpine*, Vol. 12, 1924, pp. 547–644).

An interplay of forces, geographical and historical, has determined and is determining the pattern of settlement in the Baronnies. Snowfall is here not so heavy, and mountains neither so high nor so steep, that sites must be carefully chosen to avoid avalanches. An ample water supply, widely distributed in many small springs, is well adapted for the use of individual farms. The flat plains between the hills of the Baronnies offer fields easily cultivable by modern methods and provide ready means of intercommunication. Climate and physiography would thus seem overwhelmingly to favor the dispersal of habitations over the lowland.

In response to these natural conditions, settlement in the Roman period was confined to the plains. Turbulent conditions in the Middle Ages, on the other hand, saw the removal of the population to the hills and its concentration under the protection of the *châteaux* in closely built hilltop and hillside villages. But with the fourteenth century began a gradual descent of the people into the lowlands, a descent which, though interrupted during the religious wars, has been going on ever since. Various circumstances, however, have tended to retard and complicate this movement. Before the French Revolution most of the low-lying land along the rivers formed part of wide seigniorial demesnes, and the peasants had no opportunity of acquiring holdings in it. The Revolution brought the subdivision of the great estates among the peasants, but, even so, poverty has often prevented the small proprietor from moving his dwelling place from the lofty ancestral village to his new fields in the bottom lands.

In spite of these retarding circumstances the descent of the population continues and has assumed new life during the twentieth century. It has taken many forms that are now reflected in the varied character of the habitations throughout the massif. During the earlier stages of the process the new settlements on lower ground often took the shape of villages built quite as compactly as the upland settlements left behind. Usually, however, the dispersal was a gradual one into the open country. The peasant, instead of carrying his tools back up to the village every evening from his remote fields in the flood plains, would build a small shack to house them. This would be followed by a shed for carts and agricultural machinery, then by stables, then by a temporary lodge where the owner and his family "could pass half the year amidst his fields and beasts"; finally he would sell his village house and with the money received build a suitable dwelling on the lowland.

Many of these rural habitations in form are merely modifications of the village house. In the latter the stable occupies the ground floor; on the story above the stable are the kitchen and bedrooms, reached by an exterior flight of steps; the top story is a granary. This arrangement when transferred to the open country usually is materially changed. The kitchen, for instance, is often moved to the ground floor next to the stable, thus elongating the entire structure. Frequently there ensue such complex alterations that little or no trace of the original village house form is retained. "Thus the house of the Baronnies, like the village, is in full evolution, evolution determined by the increase in wealth and the necessity of adaptation to present agricultural conditions." A fundamental principle clearly expressed by Demangeon would thus seem to be carried out in the Baronnies: "La personnalité foncière de l'habitation rurale ne se compose pas de ces éléments qui changent et qui passent; elle émane surtout de l'ordonnance interne des bâtiments qui est née de besoins agricoles" (Albert Demangeon: L'Habitation rurale en France; Essai de

classification des principaux types, *Ann. de Géogr.*, Vol. 29, 1920, pp. 352–375; reference on p. 356).

AFRICA

Agriculture in East Africa. Under this title Dr. H. L. Shantz has contributed a valuable study on the agricultural development and resources of East Africa—a vast region stretching from Abyssinia to Rhodesia and Bechuanaland. (Supplementary chapter to the report prepared by Thomas Jesse Jones: Education in East Africa: A Study . . . by the second African Education Commission under the auspices of the Phelps-Stokes Fund, New York, 1925.)

The work is based on official statistics for the several countries, colonies, and protectorates (only crude estimates for Abyssinia) and on data assembled during two trips to Africa. Of particular interest is the section dealing with agricultural potentialities. A table is provided which includes estimates of the area of the major types of natural vegetation and the area available for crops, for grazing, and for forest separately in Ethiopia, Kenya, Uganda, Tanganyika, Zanzibar, Nyasaland, Portuguese East Africa, Northern and Southern Rhodesia, and Bechuanaland. Out of the total land area for these ten countries of 2,200,000 square miles, it is estimated that 309,000 square miles in the highlands are capable of producing cool-weather crops and 1,205,000 square miles of lower-lying lands are capable of producing warm-weather crops. These estimates are based principally on the natural vegetation and to a lesser extent on the soils (see "The Vegetation and Soils of Africa," by Shantz and Marbut, *Amer. Geogr. Soc., Research Ser. No. 13*, 1923), with no allowance for steepness of slope or roughness of surface. However, the hill slopes are commonly the best land in the tropics, and the hoe system of husbandry permits their cultivation to a far greater extent than in the temperate zones where machinery is used. This estimate of 1,689,000 square miles capable of crop production, from the standpoint of climate primarily, is somewhat larger than the area of potential crop land in the United States (1,500,000 square miles). On the other hand, the 511,000 square miles incapable of crop production is only about one-third that in the United States (see "The Utilization of Our Lands for Crops, Pasture and Forests," by Gray and Baker, *Yearbook Dept. of Agric. for 1923*). This is much less proportion of arid land than has been generally believed.

The 68,000 square miles of forest are only about one-ninth the area of forest in the United States containing saw timber or timber of cordwood size; but the 764,000 square miles of woodland and open forest is three times the area in the United States of cut-over land not restocking and of arid woodland. Unquestionably the forest resources of East Africa are meager compared with those of the United States, but the grazing resources are enormous. Dr. Shantz estimates the area of grazing land of high carrying capacity (equal to or better than that in central North Dakota or central Oklahoma, i. e. five acres or less to a cow) at 1,639,000 square miles. This is over four times the area of humid and subhumid pasture land in the United States. Some of this grazing land, like the "mountain grassland," is equal to our best bluegrass pastures and unlike them is year-long. The 493,000 square miles of grazing land of low carrying capacity, however, is only about half the area of arid and semiarid grazing land in the United States. These estimates of grazing land are based on the map of native vegetation and make no allowance for the area in crops, which is known for the native population only for Uganda, Zanzibar, and southern Rhodesia. However, the total area in crops at present is, apparently, between 300,000 and 400,000 square miles, which would reduce the area of grazing land of high carrying capacity to about 1,300,000 square miles. It appears probable, therefore, that the aggregate carrying capacity of the grazing lands of East Africa at present is double that of the United States.

Accompanying the table and descriptive text is a small map for each country listed above, showing in a general way the location of the areas adapted to cool-climate crops, warm-climate crops, and grazing. It is suggestive of the altitude of much of the region that each country except Bechuanaland contains more or less land adapted to cool-climate crops.

In conclusion Dr. Shantz notes that "East Africa at the present time has a European population of about 63,000, and there are under European cultivation about 1,000,000 acres of land. . . There are 22,000,000 natives in East Africa and at present probably an equal number of acres of land under cultivation. Very little of this is devoted to export crops. . . The combined export of agricultural products amounts to about 11,000,000 pounds sterling."

In the past the Government departments have centered their activities on farms owned by Europeans; but now the importance of the native agriculture is being recognized, and in several provinces, notably Uganda and Kenya, the production of cotton by the natives has proceeded so rapidly as to engender fears for their welfare. As Dr. Shantz explains: "The demoralizing effect of the great returns for cotton production in Uganda and Kavirondoland in Kenya are deplored by many. Although the industry fits admirably into the native's system of agriculture, and although no one could question the desirability of cotton as a money crop in the section, all except those who profit directly by this sudden increase see in it a great danger to the native people. . . There is a strong need here of a stabilizing influence, one which will prevent the native from becoming a spendthrift and lead him to the accumulation of his wealth for the future use of himself and family . . . the remedy is not to decrease cotton production but to study the domestic economy of the natives and enable them to put this rapidly acquired wealth to some good advantage." The great need of the native is agricultural education, not that which will necessarily destroy his own methods of cultivation, which are often well fitted to the physical conditions, but that which will help him to adapt himself to the commercial system of production which is developing.

In conclusion Dr. Shantz outlines a plan for a survey which should include the physical basis of agriculture and the native and European methods of production, together with an enumeration of the different peoples and races, and a study of their mental background, type of agriculture, value as laborers on farms, and probable response to education; also transportation and markets. This survey will afford the basis for an educational program, which should include the establishment of a centralized scientific staff for research and extension work and should utilize Government and mission schools and all other agencies available. The whole paper is an admirable illustration of the value of geographic material and methods in the planning of an economic policy.

O. E. Baker

Climatology of Madagascar. Meteorological observations in Madagascar began as early as 1880, when a Catholic mission started to record the daily pressure, temperature, humidity, and rainfall. A regular weather service with numerous stations sending in telegraphic reports to a central office was not organized, however, until after 1900; and observations were not published until 1920. Now we have our first summary of these weather data for this large island in "Météorologie côtière de Madagascar et essai climatologique," by M. Blosset (*Bull. Économique de Madagascar*, Vol. 21, 1924, pp. 5–20, Tananarive). The data of 15 coast stations mostly covering the five-year period 1919–1923 inclusive have been used. For some stations pressure and temperature records of only one year were available, but almost all could furnish rainfall data for the complete period. Six stations had data on winds covering five years, the rest three years. The material is thus still rather inadequate for establishing climatological averages.

M. Blosset is avowedly not a climatologist but an engineer, and his graphical representations are likely to be more helpful than his discussion. His maps indicate a low-pressure center at the northern end of the island, strongest in January, usually the month of highest temperature. The southern two-thirds or three-fourths of the island is covered by a high-pressure area which is weakest in January and strongest in July, the month of lowest temperature. The pressure gradient between the two is but slight; so, too, are the seasonal temperature changes. The growth and southward motion of the low center in January is of course but a phase of the general southward motion of the doldrums, or equatorial belt of low pressure, with the sun. Madagascar has the heavy rainfall on windward shores characteristic of lofty islands in the trade-wind belt. The mountains along the east coast receive over two meters, the lower plateau region farther inland from one to two meters, and the lowlands on the west shore less than one meter. M. Blosset rather fancifully attributes the dryness of this coast to the fact that it is opposite hot and dry Africa. The African coast across the way, however, being a windward shore, is not nearly so dry. The southern hemisphere summer and fall are the rainy seasons in Madagascar, for then the doldrums are farthest south and tropical cyclones most abundant.

ELEANOR S. BROOKS

The Geography of Makalla. In the winter of 1919–1920, at the request of the late Sultan, Mr. O. H. Little, of the Geological Survey of Egypt, surveyed a portion of the interior of the Sultanate of Shehr and Makalla, on the south coast of Arabia some 294 miles east of Aden (see O. H. Little: The Geography and Geology of Makalla (South Arabia), Ministry of Finance, Survey of Egypt—Geological Survey, Cairo, 1925). His main purpose was to examine the commercial possibilities of certain lignites and oil shales which were known to exist in the region; but to serve as a basis for the geological observations a careful topographical survey had to be made, involving the astronomical determination of positions, the measurement of a base, the construction of a triangulation net, and plane-table work. The results are shown on a geological map (1:250,000), one of the few accurate maps of any portion of Arabia. Little's general conclusion regarding mining prospects was not encouraging: "though there may be a large amount of lignite available the inaccessibility and irregularity of the deposits discovered so far do not offer the prospect of profitable development for export." In addition to the difficulties of transport and water supply "the importation of labourers would only be possible with the permission of the tribesmen and as they have a strong objection to any foreigner, even a Mohammedan, entering their country, this might not be easy to obtain." Native hostility must also be overcome before any extensive search can be made for the oil which would seem to exist in this region.

Little's report gives a clear account of the district: "an exceedingly wild and rugged country consisting of highly dissected plateaux and mountain ranges through which the streams have cut deep canyon-like wadis." The highest point rises to 2187 meters (7175 feet). Through one of the wadis a perennially flowing river reaches the sea—an unusual circumstance in Arabia.

Makalla itself is a town of tall, imposing houses and about 10,000 inhabitants. It is the second port on the south Arabian coast, with a considerable export trade in "tobacco, skins, dates, wheat, honey, gums and a certain amount of limestone"; its main industries are shipbuilding and the operation of limekilns. Negroid slaves, who are "treated well, not overworked, and allowed plenty of liberty, [and] who have a lively sense of their own importance," are an interesting element in the population. The freedmen are worse off and are looked down upon even by the slaves. The late Sultan was an enlightened despot: witness his four automobiles, the special roads which he had constructed for the automobiles to run on, and the electric-light plant and waterworks which illumine and water the Royal Palace.

ASIA

The North-West Frontier of India. "Before the war, if the Canadian southern boundary, which for over a century has ceased to be a frontier in the ordinary sense, be left out of account, the British Empire had only one real military frontier, in India. . . Our permanent land frontier problem is still in India." Thus the

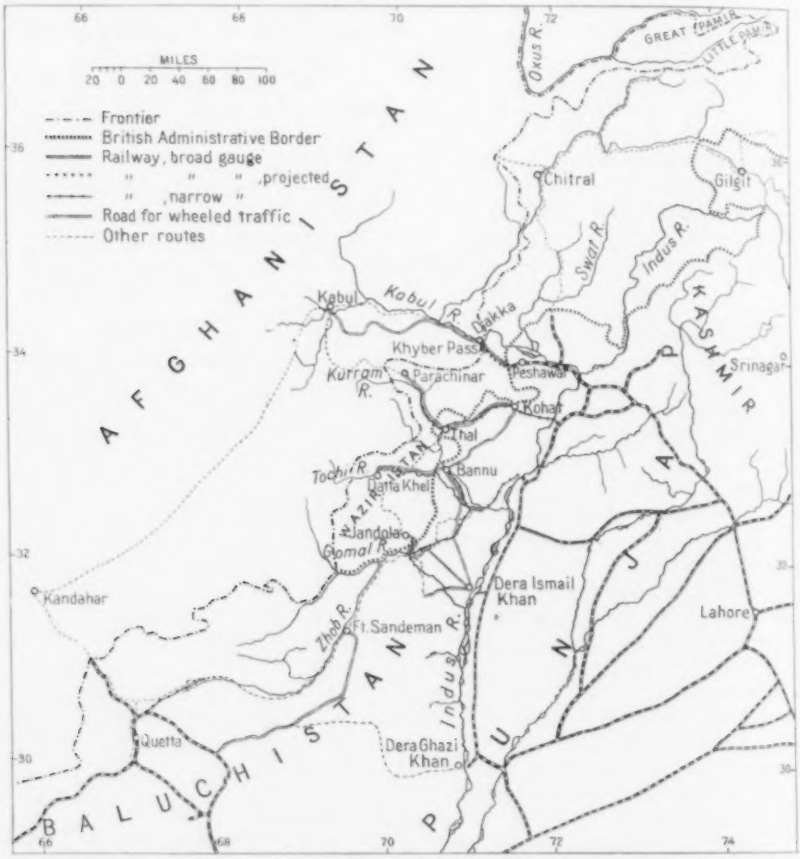


FIG. 1.—Communications on the North-West Frontier of India. Drawn from the map on page 251 of the *Journal of the Central Asian Society*, Vol. 11, 1924.

editor introduces a paper on "The Indian Frontier Problem" in the December, 1925, number of *The Round Table*. In actual usage the "Frontier" is the whole tract of country from the Hindu Kush to Baluchistan and from Afghanistan to the Indus. It includes a strip of plains land west of the Indus which constitutes four of the five districts of the Frontier Province and a 400-mile-long tangle of mountains known as Independent Territory. The area of the territory is some 25,000 square miles. The boundary with Afghanistan, the Durand line, has been accurately delimited: not so the administrative boundary, which is an arbitrary line drawn through a more or less homogeneous population.

The problem of the frontier lies in its situation as the only land gateway, and a one-way road at that, from the restless lands of the Central Asian nomad to the fat

fields of the Indian plains. "Central Asia is entered when the Indus is crossed," says Lord Montagu of Beaulieu in a paper before the Central Asian Society (The North-West Frontier of India, *Journ. Central Asian Soc.*, Vol. 11, 1924, pp. 137–146). To hold the gateway from the Indian side is strategically difficult; the roads, natural and man-made, run up the valleys; the tribesmen hold the heights. In other physical circumstances the frontier is difficult. The range of temperature is enormous. Lord Montagu speaks of summer temperatures of over 128° F. and winter temperatures below zero. The rainfall ranges from under 8 inches a year on the Baluchistan border to 100 to 200 inches and more on the Himalayan slopes to the north. There are thousands of square miles of magnificent forest and yet more of desert and drifting sand. The more arid section, Waziristan, is the more turbulent. Thence have emanated the most serious raids. Relations with the northern section are more satisfactory, and trade is active.

The total population of the Independent Territory is estimated at 2,800,000, a high figure for such a land. Here indeed lies the whole crux of the matter: "the hills breed many and feed few." The number of fighting men is placed at 600,000. As a Frontier chief said: "I only know one trade, a man's trade—war." It is the normal business of the land. How then is the Frontier to be pacified? A general consensus of opinion favors road making. One speaker in discussing the problems raised by Lord Montagu's paper (The Influence of Communications on Military and Other Policy on the North-West Frontier of India, *Journ. Central Asian Soc.*, Vol. 11, 1924, pp. 244–262) compares the situation to the Highlands of Scotland before the building of General Wade's famous roads (see John Mathieson: General Wade and His Military Roads in the Highlands of Scotland, *Scottish Geogr. Mag.*, Vol. 40, 1924, pp. 193–213). The building, upkeep, and policing of roads would provide employment for a portion of the population, strengthen the strategical situation, and permit the opening up of natural resources in the shape of minerals and forests. The country is at present held by the "five-finger" policy; four radial roads running through the hills towards Afghanistan through the Khyber Pass, the Kurram, Tochi, and Gomal Valleys respectively, and the fifth to Quetta. A lateral connecting road is strongly urged.

The Non-Chinese Peoples of Kansu. Kansu is so situated as to invite movement and mixture of peoples: a remote frontier province of China proper it marches west and north with Tibet, Chinese Turkestan, and Mongolia. In 1923 an investigation of the non-Chinese inhabitants of the province and the Alashan desert to the north was made for the National Geographic Society by F. R. Wulsin (Non-Chinese Inhabitants of the Province of Kansu, China, *Amer. Journ. of Phys. Anthropol.*, Vol. 8, 1925, pp. 293–320). As is to be expected, most of these people are related to larger groups, Mongol, Moslem, and Tibetan, dwelling beyond the regions immediately under examination. Photographs of some of the types appear in Mr. Wulsin's article "The Road to Wang Ye Fu" in the *National Geographic Magazine* for February, 1926.

The Alashan Mongols of Inner Mongolia are largely nomads. If outward appearances may be trusted, the life of the nomad is not here, as it has been in Arabia and Syria, associated either with keen wits or religious depth. Wulsin calls the Mongol healthy but "thoroughly stupid" and adds that "any Chinese coolie who has traveled seems a scholar and a philosopher by comparison." Chinese settlement has gradually advanced into the Alashan desert, and "sooner or later all but the most arid regions of Inner Mongolia will be transformed into Chinese *hsiens*."

It is estimated that there are three million Moslems (one-third of the population) in Kansu. Legend has it that some of these interesting folk are descended from "small bodies of Arabs who migrated across Turkestan to China before the year 1000 A. D."; others would seem to be of Turkish or Mongol origin, though they are all now essentially like the Chinese "in dwellings, dress, industries, methods of agriculture, etc.,

. . . except as the Koran may dictate peculiarities. Mosques are built in the Chinese style, but with towers as minarets." Though most of these Moslems speak Chinese, a few tribes use Turkish and Mongol dialects. That they are a proud, fighting folk, who resent interference with their religious liberty, is witnessed by their many rebellions against the Chinese rule, especially those of 1862 and 1895. (For an historical study of the Moslems in China, see Marshall Broomhall: Islam in China: a Neglected Problem, London, 1910; for a bibliography of Islam in China to 1921, see Henri Cordier: Bibliotheca Sinica, Paris, 1904–1924, cols. 1360–1364, 3136, and 3780–3788.)

The western borderlands of Kansu are occupied by Tibetans. The "altitude and cold of the plateaux" upon which they live have, perhaps, been their allies, rendering their country "unattractive to other peoples" and enabling them to maintain their identity in the face of wars and conquests. Below the 10,000-foot contour these people are for the most part farmers, but above that level they are nomads. The Choni Tibetans dwell in the valley of the Tao River and among the high, wild Min Shan mountains of southern Kansu, some peaks of which rise over 12,000 feet. Wulsin thinks they are a mixture of Chinese and Tibetans, though "they have acquired a distinct dialect and costume" and "form a political entity." They are good hunters and strong hill climbers.

Another group are the To Run or "earth men" who live north of the Sining River. For the most part farmers, they are often unhealthy; a stupid and somewhat squalid people, looked down upon by their neighbors. They use an unwritten language of their own, though they understand Chinese or Tibetan. Their origin is obscure.

POLAR REGIONS

The Pole of Relative Inaccessibility in the Antarctic. Mr. Stefansson's concept of the Pole of Relative Inaccessibility in the Arctic, first described in the *Geographical Review* for September, 1920, is now well known. A similar concept for the Antarctic is advanced by the Rev. J. Gordon Hayes in an address before the Manchester Geographical Society (The Exploration of Antarctica, *Journ. Manchester Geogr. Soc.*, Vol. 39–40, 1923–24, pp. 18–48). The area of the Antarctic continent is computed by Sir Douglas Mawson to be equal to the combined areas of Europe and Australia. Of this, little is known beyond parts of the coastal fringe. The length of coast line is conservatively estimated at 12,000 miles, of which between 4000 and 5000 miles have been charted.

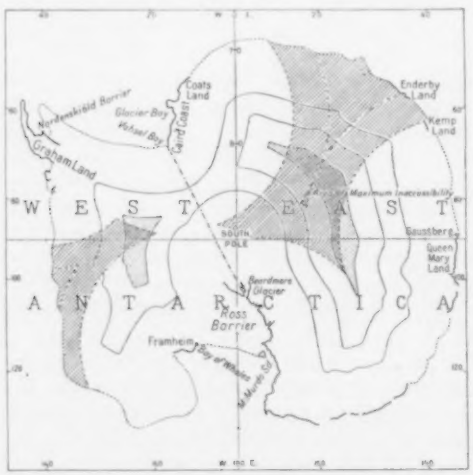


FIG. 1—Diagrammatic map showing the Pole of Relative Inaccessibility in the Antarctic. Redrawn from Figure 4 of the paper under discussion. The areas beyond the arcs of 750 miles radius are shown by diagonal ruling: the stipple represents the cores of the unknown areas.

To determine the most inaccessible area of unexplored Antarctica a modification of Stefansson's method is suggested. Inland sledge journeys are known to be possible from MacMurdo Sound, the Bay of Whales, Glacier Bay (Caird Coast), and Gaussberg; also almost certainly from Norden-

skjöld's ice shelf. It is also known that journeys of at least 750 miles can be made from some of these points. A series of arcs described from these bases is thus taken to define the most inaccessible portions. There are two such areas: a smaller one in West Antarctica, a larger in East Antarctica. Regarding the latter the comment is that it "may be even more difficult to reach in practice than appears on paper, because it may not be possible to establish a base at Gaussberg every year. Queen Mary Land is farther away, and Enderby Land, which is the obvious base for this remote area, has never yet been reached."

A rather different method of approaching the problem gives comparable results. On the map lines parallel with the limits of the unexplored region have been drawn at successive intervals, 360, 540, and, in the eastern lobe, 720 miles from these limits. The inaccessibility of the heart of East Antarctica is emphasized. All this, of course, ignores the question of special topographical obstacles that the great plateau may offer, but it can be said with probability that the pole of inaccessibility lies about halfway between Kemp Land and the mathematical Pole.

THE OCEANS

The Sargasso Sea. In an article in the *Geographical Journal* for November, 1925, Captain C. C. Dixon summarizes the results of observations made during 29 passages through the Sargasso Sea. On the basis of these observations he estimates 20,000,000 tons of floating *Sargassum*, or "gulfweed," in the Sea.

With regard to the origin of the gulfweed Captain Dixon expressly states that he has little information. But on the assumption that this gulfweed is renewed by the addition of plants from the Caribbean Sea and Gulf of Mexico, practically all of which must pass through the Florida Strait, he estimates that the floating weed in the Sargasso Sea is renewed every four years. In this connection, however, it is to be recalled that a strong case for the independent existence of the gulfweed in the Sargasso Sea has recently been presented by Dr. Ö. Winge in one of the "Miscellaneous Papers" of the "Report on the Danish Oceanographical Expeditions, 1908–10, to the Mediterranean and Adjacent Seas" entitled "The Sargasso Sea, Its Boundaries and Vegetation" (*Geogr. Rev.*, Vol. 15, 1925, pp. 149–150).

Captain Dixon concludes that the Sargasso Sea is either slowly changing its position or decreasing in area, reports eighty years ago indicating the presence of the gulfweed some 600 miles southeasterly of its present southeastern boundary. The delimitation of the Sargasso Sea by Captain Dixon agrees in the main with that of Dr. Winge, the only sharp difference being a greater northward extension of the northeastern boundary on Captain Dixon's map.

H. A. MARMER

Influence of the Antarctic on the Ocean Waters. The oceanographic results of the German South Polar Expedition in the *Gauss*, 1901–1903, are summarized by Professor Erich von Drygalski of Munich, the leader of the expedition, in an article entitled "Ozean und Antarktis," published in a recent issue of *Die Naturwissenschaften* (Vol. 13, 1925, pp. 701–704). Drygalski accepts Wagner's figures of fourteen million square kilometers (five and one-half million square miles) for the area of the Antarctic continent and recognizes as Antarctic the whole of this continent and the shallow sea covering the continental shelf. Over all this the effect of the ice is predominant; but immediately north of the marginal sea the ocean waters are subantarctic in their physical and biological characteristics. In these ocean waters the effect of the Antarctic ice is felt only in two layers, namely, the upper layer and the bottom layer, while the middle layer consists of water of a higher temperature.

This stratification Drygalski explains as follows: The polar water from the marginal Antarctic sea moves northward spreading through the upper layer of the ocean

waters. In its northward journey this polar water responds to change of latitude by increase in temperature but without changing much in salinity. The middle layer, because of its higher temperature and salinity, must be assumed as arising in lower latitudes. The bottom layer has a temperature higher than the upper layer but lower than the middle layer. Its origin, therefore, is to be found in the mixing of the waters of the upper and middle layers. This mixture, being cooler than the middle layer, has a greater density and hence sinks to the bottom. The lower layer, which extends northward to the equator, thus owes the Antarctic only its lower temperature.

The causes bringing about the movements of the water which carry the influence of the Antarctic to lower latitudes, Drygalski finds in wind currents and convection currents. In conclusion, however, he finds it necessary to assign to the Antarctic a lesser influence on the oceans than is currently accepted, for the primary forces are to be found in the tropics and not in the polar regions.

H. A. MARMER

The Atlantic Ocean Tide. Over the wide expanses of the open ocean nothing is known of the rise and fall of the tide from direct observation, for tidal observations have been confined almost without exception to the immediate vicinity of the coast. On the so-called cotidal maps which show the time and progression of the tide over the various ocean basins, the only points definitely fixed are those along the coast, while across the open sea the cotidal lines must be drawn in accordance with certain assumptions. And it is these assumptions that determine the characteristic features of the tidal régime as delineated on a cotidal map.

The first cotidal map for the Atlantic Ocean, drawn by William Whewell in 1833 (*Philosophical Transactions*, 1833, pp. 147–236), represented the tide as having its origin in the Southern Ocean, the belt of water that completely encircles the globe southward of the great land masses. Here, it was thought, the tidal forces have almost uninterrupted sway; hence the moon in its journey around the earth compels the tide in this belt of water to keep time with its own motion. And as this primary Southern Ocean tide wave sweeps past the Cape of Good Hope it was conceived as giving rise to a secondary wave which travels up the Atlantic Ocean as a progressive tide wave. Forty years later, however, William Ferrel as a result of his tidal researches concluded that the tide in the North Atlantic Ocean was due primarily to an east-and-west stationary-wave oscillation. He therefore discarded the notion of a progressive wave sweeping up the Atlantic from the Southern Ocean, and he emphasized his views by the statement "If there were a dike extending from the Cape of Good Hope to the coast of South America, the tides of the North Atlantic Ocean would most probably be very nearly the same" (Tidal Researches, Appendix, *U. S. Coast Survey Rept. for the Year 1874*).

To this question of the Atlantic Ocean tide Professor Albert Defant of Innsbruck has recently contributed an important hydrodynamic study (Die Gezeiten des Atlantischen Ozeans und des Arktischen Meeres, *Annal. der Hydrog. und Marit. Meteorol.*, Vol. 52, 1924, pp. 153–166 and 177–184). Defant considers the Atlantic and Arctic Oceans as constituting an enormous canal open only at its southern end (the narrow and shallow Bering Strait on the north, in comparison, may be disregarded), and he then studies mathematically the tide waves which such a canal can sustain and the relative importance of these various tidal oscillations in bringing about the actual tide. In the Atlantic Ocean, as is well known, the semidaily tide is the predominating one, and on investigating the semidaily oscillations possible in the Atlantic, Defant finds that it is the north-and-south stationary-wave oscillation dependent on the tide in the Southern Ocean that determines the tide in the Atlantic and Arctic Oceans. Six nodal lines are indicated by the mathematical analysis, but the effect of the deflecting force of the earth's rotation is to convert four of these no-

dal lines into amphidromes, that is regions from which cotidal lines radiate. For the greater part of the Atlantic Ocean the tide behaves as if it were a progressive wave coming from the Southern Ocean. But Defant emphasizes the fact that this is only an appearance, due to the interaction of north-and-south and east-and-west stationary-wave oscillations and not to an actual progressive wave sweeping in from the Southern Ocean.

For the daily tide in the Atlantic, Defant finds that it is the independent oscillation of the whole canal-like basin in the direction of its length that gives rise to the principal component. The relatively unimportant rôle of the daily tide in the Atlantic, as compared with the semidaily tide, he ascribes to the fact that at the mouth of this canal the Southern Ocean daily tide has a nodal line so that no dependent oscillation arises therefrom in the Atlantic to reënforce the independent daily oscillation. The satisfactory agreement of the results derived by Defant from his mathematical analysis with the results derived by Harris and Sterneck from existing observations proves that the conception of the Atlantic and Arctic Oceans constituting a huge canal closed at the north and open at the south is a valid one.

H. A. MARMER

PHYSICAL GEOGRAPHY

The Use of Glacial Boulders in Ore Prospecting. "All new discoveries of ore deposits made in Finland during the last few decades have got their first impulse from the finding of glacial boulders derived from those deposits," says Matti Sauramo in the introduction to his paper, "Tracing of Glacial Boulders and Its Application in Prospecting" (*Bull. Commission Geol. de Finlande No. 67*, 1924).

The problem lies in the tracing of the drift boulder to its source. This requires that the direction and distance of transportation between the time of dislodgment and deposition be determined. As a result of the facts ascertained in Finland, Sauramo demonstrates that mapped boulder trains of known derivation are the best available indicators of the *direction* of ice transportation. Striae are comparatively unreliable indicators. Mapped boulder trains (that is the plotted distribution of all the boulders of the type of special interest, found in the large or small area over which they are scattered) also permit of deductions regarding the *distance* of the source. Experience shows that they are fan-shaped, and lines representing the marginal limits of distribution may be projected towards a point of intersection; the suspected position of the source is at the apex of the boulder train. An abundance of boulders of the same kind within a small area indicates, as a rule, a source near by; their scarcity, however, does not imply a distant source.

If but few boulders of the sought-for type can be found, search for a near-by source may be made in the direction indicated by local glacial striae. If, by elimination, a distant source is indicated, the striae may be regarded as having little value in directing the search. There remains, however, a chance for success in regions that have been geologically mapped in detail. Boulders of distinctive lithological character of known remote source may be found associated in the till with the boulders of special interest, and the direction of transportation can be thus deduced. The search may be carried on continuously toward the inferred source, and special examinations may be made of the areas known to have supplied boulders associated with the sought-for material.

Sauramo outlines three main factors likely to confuse or render difficult the tracing of glacial boulders. (1) Secondary boulder trains may develop by the breaking and dispersion of huge primary boulders in moving ice, and these fan-shaped trains do not indicate the true source. (2) Esker materials are usually of distant derivation and are of little value in indicating the source of blocks. (3) Over areas of marine submergence and in the basins of postglacial lakes, the erratics may have been

transported by floating ice which moved in variable directions independent of the movement of the land ice.

T. L. Tanton

Erosion by Solution and Fill. What may be considered as a modified type of karst topography is found in the valley of the Pecos River in southeastern New Mexico. The valley here consists of "a succession of broad, shallow depressions," which Willis T. Lee (Erosion by Solution and Fill, *U. S. Geol. Survey Bull. 760–C*, Washington, 1925) ascribes in the main to "local subsidence due to the removal by solution of soluble rock near the surface." The region is predominantly one of limestones and gypsums which dip gently to the southeast. In these beds a great many solution cavities have been formed—among them Carlsbad Cavern, which, "because of its size and the splendor of its onyx decorations . . . has been made a national monument." The cavernous condition would seem to extend to a depth of at least several hundred feet below the surface. As is frequently true of streams in the karst regions of Dalmatia or Greece, in one place "the entire flow of Pecos River goes underground . . . and reappears farther downstream." The roofs of many of the subterranean caverns have collapsed, some having done so since the region has been settled. One settler is said to have "found one morning in front of his house a hole sixty feet in diameter and about 150 feet deep." So great is the amount of surface débris washed into the sink holes and caverns and of soluble material deposited by the waters flowing through them, that they are gradually filling up, and their places being taken by shallow basins.

Limiting Values of Temperature and Rainfall Over the World. The discussion of limiting values of temperature and rainfall is of special interest to geographers. On this theme Hellmann has a most interesting and instructive paper, "Grenzwerte der Klimaelemente auf der Erde" (*Sitzungsber. Preuss. Akad. der Wiss., Phys.-mathem. Klasse*, 1925, pp. 200–215).

The world maximum temperature, 56.6° C. (134° F.), seems to have occurred in Death Valley, California, at Greenwood Ranch, July 10, 1913. Hellmann thinks it should probably be reduced to 56° C. (132.8° F.) to allow for heating of the thermometer by radiation from the ground, an ever present difficulty of observation in the desert regions, where the highest temperatures are observed, because of the great degree to which the ground is then heated, 70° C. (158° F.) being possible. The hot day was the third in a spell of seven, all above 52.7° C. (127° F.). Other very high records are noted from the American Southwest, the desert of Egypt, and Jacobabad, western India, which had 126° in June, 1897.

Many high records reported must be pronounced doubtful. The recently reported world record of 58° C. (136.4° F.) from Azizia, Tripoli, is probably too high because of imperfect sheltering of the thermometers from the reflection of heat from the ground. The record was reported by Eredia for September 13, 1922. Azizia is about 40 kilometers south of the port of Tripoli. There was a cloudless sky and southwest wind. "It seemed to me at once striking that so high a temperature should occur so near relatively to the sea, and in a place of only half-desert character." On investigation Hellmann found four other stations in Tripoli which gave temperatures 10° C. (18° F.) lower that day or the day before, i. e. Tripoli, Sidi Mesri, Homs, and Quana Marina. The same thing occurred in 1923, when Azizia had a maximum of 57.3° C. (135.1° F.). The other stations, now nine in number, all had records 10° C. or more lower. His conclusion is that the instruments were not properly protected from reflection or were situated in a hollow in the ground.

The reviewer's attention was specially arrested by the fact that the record occurs at a date near the equinox. The hottest temperatures in the world occur just outside the borders of the tropics and at the time of the summer solstice, because the high

sun of the solstice then shines for the longest possible day. These two elements with the bareness of the ground on which the subtropical sun so frequently shines combine to give these two belts about the world their high maximum temperatures. But Azizia was said to get its record maximum in September. Why, it was difficult to understand. It is a relief to have Hellmann cast suspicion on the record for an independent reason.

The highest mean monthly temperature of the world as well as the absolute extreme seems to occur at Death Valley: it is 38.9° C. (100° F.) for June. Nearly as high values are recorded from Jacobabad in India and on the Red Sea and Upper Nile.

The highest mean annual temperature is reported from Massawa, an island off shore in the Red Sea. There are 16 years of observation and the mean is 30.2° C. (86.4° F.), a high average because a high maximum is combined with a minimum that is relatively still higher—maximum 34.1° C., minimum 26.3° C. (79.3° F.). The nights do not cool off! That is what makes the Red Sea so uncomfortable. Very likely the coastal plain of Yemen opposite gets as hot, but there are no observations. Italian and English Somaliland are about as hot as Eritrea, Pondicherry not so hot as reputed.

For the coldest temperature as yet noted the record of −67.8° C. (−90° F.) is with Verkhoyansk in Siberia, 67° 6′ N., 133° 9′ E. The dates are January, 1892 and 1885. The observations were made with alcohol thermometers, as mercury freezes there; and H. Wild estimates the equivalent on the air thermometer at −76° C. (−105° F.). The polar regions show nothing comparable.

The lowest known mean for a month is −51.2° C. (−60.2° F.) at Verkhoyansk. The hollow valley of the Yana, in which the cold air gathers, is usually calm in great cold. The still cold is not painful to bear, "one must merely take the precaution not to breathe the air directly but to let it draw first through the hair of the fur which protects the mouth." The most painful degree of cold is undoubtedly at the borders of the Antarctic continent when the wind blows with steady violence, though the air is not so cold.

In the Antarctic, too, at Amundsen's headquarters at Framheim (78° 38′ S., 163° 37′ E.) occurs the lowest mean annual temperature of record, if the future maintains the values observed in the brief series of observations. This is −25.8° C. (−14.4° F.). It is thought that the lofty south polar regions, 2500 meters, and still more elevated Greenland ice cap, 3000 meters, would go to an annual average of −30° C. (−22° F.) and −32° C. (−25.6° F.) respectively, probably warmer than Framheim when reduced to sea level.

Rainfall is probably still to be regarded as greater at Cherrapunji than at any other place in the world. The station lies on the plateau of the Khasi hills at an elevation of 1250 meters. The rain amounts to from 11,000 millimeters to 12,000 millimeters (432.96 inches to 472.32 inches) a year. The plateau lies northeast of Calcutta and rises sharply from the lowland of Bengal in the face of the summer monsoon. Sylhet, at the foot of the hills, gets only 4033 millimeters (158.73 inches); and Shillong, on the northeast side in the rain shadow, gets but 2057 millimeters (80.96 inches). There are a number of points of observation, four apparently at the height indicated, 1250 meters. The records are of different lengths:

49 years at the Police Station, 10,867 millimeters (427.73 inches)
18 years at the Welsh Mission, 11,219 millimeters (441.58 inches)
12 years at Shadwell's House, 11,421 millimeters (449.53 inches)

There are also five years of observation at the near-by station of Manoyuram at 1067 meters, with a mean rainfall of 12,665 millimeters (498.49 inches). That is the highest of all, but of course the records are not comparable either in epoch or length of series of observations.

There is a station at 1547 meters on the summit of the volcano Waialeale, which occupies most of the Hawaiian island Kauai in the northeast of the group. The first five years gave an average rainfall of 12,090 millimeters (475.86 inches). This is the path of the northeast trades. One "year," from May 21, 1915, to May 30, 1916, gave 14,249 millimeters (560.84 inches), but the station Puu Kukui, at 3058 meters, on the island Maui, in the midst of the Hawaiian group, had a smaller annual mean rainfall but the large annual catch in 1918 of 14,275 millimeters (561.86 inches). Cherrapunji is said to have recorded 15,011 millimeters (590.83 inches), but Blanford marks this record with a question mark.

From all of this it is evident that it is no simple matter to answer the question, where does the greatest rainfall occur? There is still need, in the reviewer's opinion, of many more years of carefully made observations and especial need of a great number of gauges in mountains which are still mostly unexplored as regards rainfall, as Wallén's work on the outflow from the lakes of northern Sweden demonstrates.

The west slopes of the Cameroons mountains had heavy precipitation down at sea level, the plantations Debundja and Bibundi reporting, for 11 and 8½ years, 10,469 millimeters (412.06 inches) and 10,242 millimeters (403.13 inches) respectively. On the mountains above it is likely the heaviest rains of the world will yet be measured.

As for the least rainfall of the world, rain undoubtedly falls everywhere. Upper Egypt was formerly reported to be entirely rainless, but the establishment of rain gauges invariably results in the catching of rain. Wadi Halfa, in latitude 21° 55′ N., had no measurable rain in the ten years 1891–1900, but *raindrops* were noted in that period on 22 different days! Only the years 1895 and 1898 were without even drops. Yet the desert has violent rainstorms on occasion. The smallest rainfalls known by long years of observation are in the Chilean desert, five millimeters being recorded for Iquique in latitude 20° 2′ S.

The greatest monthly rainfall is at Manoyuram, a July average of 2852 millimeters (112.25 inches). If we are to count the "days of rain"—a concept so indefinite that it is not really possible to compare different series of observations—we have to note that Jaline in the Marshall Islands has 336 rainy days a year, a rain probability of 92 per cent. The lighthouse on the Evangelistas Islands at the western entrance to the Strait of Magellan averages in 15 years 317 days of rain a year. Occasionally it rains every day for a month. In 1908 it rained continuously for 121 days. No month has less than 16 days of rain on an average. All southern Chile west of the Andes has many rainy days. So has the Atlantic east of Cape Horn and southward. Also many windward mountain slopes in the trades of the Caribbean, in Porto Bello, Panama, Bluefields, Nicaragua, and the islands St. Vincent, Martinique, and Trinidad, always on the eastern side, have more than 300 days of rain. Monsoon India has of course a good many places that have summer months with rain every day. The same thing is reported in the Cameroons, Addis Ababa in Abyssinia, Bagino in the Philippines, Nossi Bé in Madagascar, and others.

MARK JEFFERSON

The Distribution of Thunderstorms. Thunderstorms are naturally of great human interest. They are to be numbered among the most violent atmospheric phenomena with which man has to contend. On the other hand they often bring beneficent rains and are thus economically important from the point of view of agriculture, water supply, and irrigation. No map showing the annual distribution of thunderstorms over the globe has been published since that of A. Klossovsky (1892). This was reproduced, in colors with a short descriptive text, in the "Atlas of Meteorology" (Pl. 28). Klossovsky's was a pioneer effort and, valuable as it has been, was based on data for only 439 stations, 72 of which were in European Russia. The need of a later map of thunderstorm distribution has now been met by Mr. C. E. P. Brooks,

of the British Meteorological Office (The Distribution of Thunderstorms over the Globe, *Geophys. Memoirs No. 24*, Meteorological Office, London, 1925). In so doing, he has satisfactorily filled in one of the notable gaps in meteorological cartography.

The unit adopted was the "Day with Thunder Heard," according to the definition of the International Meteorological Committee. There is obviously considerable lack of uniformity and consistency in such records, but in the main the results can be regarded as at least reasonably accurate. The total number of stations employed was 3265. In addition, the results of various tabulations of marine data were used for the oceans. The basis of the investigation was Klossovsky's pioneer chart. The percentages of days when thunder was heard are calculated for the year, for April–September, and for October–March (Figs. 1–3). These three charts satisfactorily cover the question of thunderstorm frequency for ordinary purposes. There appear to be six areas of maximum annual frequency, viz. southern Mexico, Panama, Central Brazil, Central Africa, Madagascar, and Java. The last, with 61 per cent, is probably "the most thundery region of the earth"; and this fact, as the author points out, may well be taken into account in planning air routes to Australia. The Arctic and Antarctic naturally stand out as regions where thunder is rarely heard. The average frequency of thunder north of the Arctic circle is about one day in ten years. On the Antarctic continent thunder appears to be unknown. The two subtropical belts of high pressure are regions of minimum thunderstorm activity. There is a specially marked deficiency in the southern belt along the coast of Chile from 16° to 34° S.

The April–September chart naturally reproduces, for the northern hemisphere, the essential features of the annual chart with the percentages nearly doubled over the northern temperate regions. On the other hand, in October–March there is an almost complete absence of thunder north of latitude 50° N. except for the winter thunderstorms of the northwestern coasts of Europe.

In addition to the three charts here referred to, Mr. Brooks has investigated several other important conditions of thunderstorm occurrence, e. g. the total number of thunderstorms occurring in a year, the annual and diurnal variation of thunderstorm frequency, and the variation in thunderstorm frequency with height.

R. DEC. WARD

HUMAN GEOGRAPHY

European Migratory Movements. It is astonishing—if true—to learn that movements of migration affected some five millions of people every year before the World War. It is a merit of an article by Jean Morellet, "Les mouvements migratoires européens" (*Rev. des Sci. Polit.*, Vol 48, 1925, pp. 404–434), to call attention to this fact, concealed beneath local national figures of emigrants and immigrants. Here is a world movement that must sooner or later have world treatment.

The great sources of these currents at present are Italy, United Kingdom, Poland, and Spain. The examination of national statistics of course always brings up the closing of the wide-open door in the United States, which seems to astonish Europeans as much as it annoys them. A rather singular item is the hastening of Scandinavian immigration in 1923 in apparent anticipation of the coming restrictions. No immigration could be more acceptable here than that from Scandinavia; yet our receipts from Norway, Sweden, and Denmark are now limited to 18,800 individuals. Immigrants from those countries in 1923 numbered 48,200, so that we seem incidentally to be excluding people we want. South America is getting more because of American exclusion, very notable being the gain in the Argentine; but that appears not to satisfy would-be immigrants from Europe, and an increase of emigration to continental countries is perceived.

The main country to receive the surplus in Europe is France. This appears in the official figures, and the author believes there is a great "clandestine" movement. Two emigration countries, Spain and Portugal, make poor success at counting their emigrants, Spain reporting 1709 to Brazil and 42,716 to the Argentine, though the Brazilian and Argentine governments counted the landing of 10,000 and 54,000 Spaniards respectively at their ports in the same year. So the Portuguese government could only count 15,000 departed from its shores in 1923, in which year Brazil counted 31,866 Portuguese arrivals, France 11,767, United States 2500, and the Argentine 3000—an extraordinary multiplication of the original 15,000.

With Italy the emigration, which was 872,000 in 1913, fell to a minimum of 28,000 in 1918 but has now risen again to 402,000 in 1924, 271,089 of them going to other European countries, mostly to France. Morellet thinks the hidden emigration amounts to a third more. Italy is content to have her emigrants go because of the hardships of life at home and because of the exuberance of her population; but she desires to hold their Italian allegiance, even in foreign lands, even studying the possibilities of participation in national elections in Italy by colonists abroad.

British colonization was 389,000 in 1913, fell to 10,000 in 1917 and 1918, and has risen to 155,000 in 1924, with 64,000 reported coming into the country. Mostly this British emigration is different from the Italian in that the emigrants are not lost to Britain. They remain within the Empire. Even in the United States, where 34,000 a year are still admitted, they are within the sphere of English speech and thought.

France had an official immigration of 240,000 in 1924 and 47,000 departures. The incomers are largely Polish miners and Italian, Polish, or Slovak farm laborers, augmented in the south of France (1922) by 36,000 Spaniards counted and considerable numbers uncounted. Certainly the Spaniards are most abundant there, and across the Mediterranean in Oran there are probably more Spaniards than Frenchmen. Among the boatmen in the port one hears only Spanish spoken. In France the immigrants are most welcome as a means of replacing the failing growth of native population. Like other Frenchmen, Morellet has little fear that France will fail to make her immigrants over to the French psychology. If they are contented and remain they will be French, and French traditions will be in no danger. All too soon their families will be as small as any Frenchman's!

In Poland and Czechoslovakia the establishment of the new nations was accompanied by a large abnormal immigration of nation-lovers—in the Polish case one or two millions. That has now ceased, but the currents of continental migration cannot yet be called normal.

MARK JEFFERSON

The Galápagos and Guadalupe Island: Illustrations of Man-Caused Devastation. It seems probable that in name alone will the Galápagos conserve a souvenir of their first claim to distinction—their giant land tortoises. "It is incredible to report how numerous they are," says Dampier in 1684. One specimen only was seen by the Harrison Williams Expedition in 1923. Since the discovery of the islands a constant toll has been taken by early explorers, buccaneers, passing merchantmen, sealers, and whalers. Of the particularly heavy demands of the last named some notion is given by Charles Haskins Townsend in a paper "The Galápagos Tortoises in Their Relation to the Whaling Industry" (*Zoologica*, Vol. 4, 1925, pp. 55–135) based on ships' logs in the libraries of New Bedford, Nantucket, and Salem. The logs of 79 whalers, representing a total of 189 voyages made between 1831 and 1868, were examined. Their combined catch of Galápagos tortoises was over 13,000. This, however, is only a fraction of the total carried away, for at one time there were more than 700 vessels in the American whaling fleet and the majority made repeated voyages to the Pacific. A total of 100,000 would be a modest estimate.

"Turpining" in the sun-baked cactus-and-thorn-filled gullies of the islands was arduous work, and the whalers did not penetrate far inland. Destruction in the interior has been accomplished largely by settlers, who hunted the tortoise for oil as well as for meat, and by the wild dogs. In view of the destructiveness of these two agents conservation of the tortoises on the islands would appear impossible. The New York Zoological Society, however, hopes to prevent extinction of these interesting reptiles by removing survivors to some suitable locality. The case of the giant tortoises under government protection on the Seychelles is cited. The food value alone is considered sufficient justification for such a step.

In passing, Mr. Townsend makes brief mention of the origin of the Galápagos fauna. He criticizes the theory of a land bridge, asking why it was so little used if it existed.

Another instance of the lamentable destruction of an island's resources is described by Laurence M. Huey in *Science* (No. 1581, Vol. 41, 1925, April 17, pp. 405–407). The volcanic peak of Guadalupe lies some 150 miles west of the coast of Lower California. As in the case of the Galápagos, isolation has led to differentiation from mainland forms. The introduction of the mouse and cat, presumably by sealers, and later the goat by the whalers has ruined the plant and land animal life. The fur seal has been exterminated from the shores, and the elephant seal reduced to the verge of extinction. Mr. Huey observed a number on the beach in 1923 and again in 1924. These constitute the only known herd of northern elephant seal; hence one notes with gratification the news that the island has been made a Federal reservation by the Mexican Government.

The Study of Rural Settlement. Among the most interesting resolutions adopted at the International Geographical Congress at Cairo last year was Professor Demangeon's plan for the organized study of the geography of the rural habitation. Studies are to be carried on specifically in western Europe, and a report is to be prepared for discussion at the 1928 Congress to be held in England. The *Geographical Teacher* (Vol. 13, 1925, pp. 199–205) publishes Professor Demangeon's paper read before the Congress and some of the comments thereon.

The factors commonly invoked to explain the contrasted types of compact and isolated settlement are the abundance or scarcity of the water supply, the needs of defense, the type of agriculture, and ethnic tradition. M. Demangeon considers the ethnic theory untenable. The agrarian system, he holds, affords the only reasonably satisfactory explanation. Isolated farms may be very ancient in lands where stock raising has long predominated, compact villages with communal cultivation on lands early tillable.

Dr. Fleure urges that in view of M. Demangeon's claims for the antiquity of the compact village in southern France the English village should be reëxamined. Among other aids to study he mentions O. G. S. Crawford's air maps (compare the note "Aerial Survey as an Aid in the Prehistoric Geography of Southern England," *Geogr. Rev.*, Vol. 13, 1923, p. 616). Other forms of settlement in agricultural districts are also indicated.

Italy shows, perhaps in a more marked degree than any country of western Europe, contrasts between dispersed and compact settlements, says Professor Marinelli. As illustration of the former he cites the *mezzadria*, a scheme of diffuse colonization characteristically developed in Tuscany (see also Donald Gray: Farming in Tuscany, *Geogr. Teacher*, Vol. 12, 1924, pp. 430–433). A complete contrast holds in Sicily where a feudal régime long survived and where a system of monoculture (chiefly grain or vine) permitted, and the prevalence of malaria encouraged, the gathering of the peasantry into towns. Professor Biasutti also speaks of the antiquity of this type of settlement in southern Italy, so deep-rooted in the habits of the people that it does not readily yield to the general movement of dispersal.

HISTORICAL GEOGRAPHY

The English Search for a Northwest Passage in the Time of Queen Elizabeth. This is the title of a doctoral dissertation by G. B. Manhart, one of two published by the Press of the University of Pennsylvania in a volume entitled "Studies in English Commerce and Exploration in the Reign of Elizabeth," Philadelphia, 1924. It is a valuable contribution to our knowledge of a dramatic but somewhat futile chapter in the history of exploration.

The Englishmen of Elizabeth's day "with a surprising approach to unanimity" thought that a route to the Indies "existed to the north of the American continent." Their arguments were guided rather by enthusiasm than by a critical spirit of scientific research. "They used every statement in the writings of ancient and contemporary scholars which by any chance they could construe as supporting their hopes; they placed full confidence in the maps made by guess—so far as the northern regions were concerned—by men of other nations; . . . and they persuaded themselves from their inadequate observations of the depths of the sea at various places . . . that there must be such a passage."

The main part of the thesis is devoted to the three voyages of Martin Frobisher in 1576, 1577, and 1578; the three voyages of John Davis in 1585, 1586, and 1587; and the voyage of George Waymouth in 1602. Interesting details are given not only about the actual explorations themselves but also in regard to the preparations for the voyages and the personalities and commercial and political interests involved. Frobisher's voyages made much more of a contemporary sensation than those of Davis. The latter's work, however, was of greater scientific value. The seven voyages did not come anywhere near solving the problem of the northwest passage, an exploit nearly achieved by McClure in 1851 and only finally accomplished by Amundsen in 1903–1906. On the other hand they brought about an increasing knowledge of polar navigation and conditions and paved the way for the explorations of Knight, Hudson, Button, Bylot and Baffin, Edge, Foxe, and James in the generation immediately after. The actual geographical discoveries—or perhaps "rediscoveries," if we are not to forget the Norsemen—made during this first phase of the great quest included the southwestern inlets of Baffin Land, the shores on both sides of Davis Strait, and the entrance to Hudson Strait.

Manhart points out that many of the facts emphasized by Stefansson regarding the Arctic, such as the prevalence of animal and vegetable life and the warmth of the summers, were noted by the Elizabethan explorers. George Best, who accompanied Frobisher, mentioned the "convenient, moderate and temperate heat" of the Arctic summer. Davis wrote, "Three times I have been within the Artick frozen zone, where I found the ayre very temperate, yea and many times in calme wether marueilous hot," at times "as hot there as it is at the ylls of cape de Verde." He also referred to "divers kinde of foules and beastes" and "such abundance of moskeetes . . . as that we were stung with them like lepers."

GEOGRAPHICAL NEWS

Twenty-second Annual Meeting of the Association of American Geographers. The Association of American Geographers met at Madison on December 30 and 31, 1925, and January 1, 1926, for its twenty-second annual meeting. The sessions, which were well attended, were held in Science Hall of the University of Wisconsin. Professor R. H. Whitbeck, President of the Association for 1925–1926 and head of the Department of Geography of the University of Wisconsin, occupied the chair. Members of the Association and others present were guests of the Department at luncheon on December 30 and 31. At a round table for members only, matters of business and policy were discussed. Of the thirty-two papers announced on the final program,

four were not presented, seven dealt with general or non-regional topics, fourteen with topics relating to the United States, five with topics relating to America outside the United States, and two with topics relating to Europe.

Three special sessions were held, each devoted to papers on allied subjects: the Caribbean region, field geography, and urban geography.

The session on the Caribbean Region opened with an introduced paper by Dr. Glenn T. Trewartha of the University of Wisconsin, in which recent publications on the problem of white acclimatization in the wet tropics were analyzed. To the Caribbean region more particularly were devoted a paper read by Dr. Robert S. Platt of the University of Chicago on "The Railway Pattern of Central America" and three regional studies presented by Dr. Preston E. James (introduced) of the University of Michigan on a geographical reconnaissance of Trinidad; by Professor S. S. Visher of the University of Indiana on Jamaica; and by Professor A. K. Lobeck of the University of Wisconsin on Porto Rico.

The session on Field Geography was given over exclusively to discussions of the study and mapping of very small areas in the North-Central States of the United States. Dr. D. H. Davis of the University of Minnesota treated the scientific and social objectives in a geographical field study of a community which combines both rural and urban elements; Dr. Derwent S. Whittlesey of the University of Chicago read a paper entitled "An Experiment in Mapping a Small Section of the Door Peninsula, Wisconsin, for Use in Geographic Study" based on field work carried out in the summer of 1925 with the object of working toward a uniform standard in the mapping of the topographical and land-use features. Professor K. C. McMurry of the University of Michigan, in a paper entitled "A Study in the Use of Soil Types in Geographic Mapping," illustrated by reference to a survey carried out in southern Michigan the desirability and feasibility of the geographer's familiarizing himself with the outstanding soil elements of a region. A paper by Professor V. C. Finch (University of Wisconsin) on "Culture and Landscape at Madison, Wisconsin" was especially welcome for its concise view of the urban geography of the city in which the sessions were being held.

The papers read at the session on Urban Geography were all on matters primarily of industrial interest. Dr. Richard Hartshorne (introduced) of the University of Minnesota gave a penetrating analysis of many factors in the localization of the iron and steel industry that have been overlooked by earlier students of this subject. Two other papers were devoted to regional developments in the same industry, one by Dr. John B. Appleton of the University of Illinois on "The Calumet Steel District" southeast of Chicago; the other by Mr. John W. Frey (introduced) of the University of Wisconsin on "The Iron and Steel Industry of the Middlesboro District, England." Papers by Professor Frank E. Williams of the University of Pennsylvania and Dr. Lewis F. Thomas (introduced) of Washington University, St. Louis, dealt respectively with industrial growth from colonial times in Delaware County, Pennsylvania, particularly along the fall-line streams, and with the "Localization of the Wholesale and Jobbing Industries in Metropolitan St. Louis." Professor Howard H. Martin (introduced) of the University of Cincinnati outlined the geographical phases of the work of the recently organized Cincinnati Resource Survey.

Of the thirteen papers not read in the special sessions, no less than seven were on matters of economic geography. These included contributions by President W. W. Atwood of Clark University on the "Settlement and Economic Development of the San Juan Region of Colorado," by Mr. Raus M. Hanson (introduced) on "Geographic Factors in Railroad Revenues of Nebraska," by Miss Ella M. Wilson (introduced) of the State Normal College, Ypsilanti, Michigan, on potato culture in Aroostook County, Maine, and a broad survey by Dr. Helen M. Strong entitled "Cargo Movements in American Foreign Trade." Dr. W. O. Blanchard of the University of Illinois outlined the history of the forestation of the Landes in south-

western France. Professor J. Paul Goode of the University of Chicago and Dr. O. E. Baker of the U. S. Department of Agriculture reported material progress in the compilation of an atlas of economic geography being prepared under their joint authorship. In the final paper of the meeting Dr. O. E. Baker showed by means of maps prepared by the U. S. Department of Agriculture certain striking changes in the use of agricultural land that have accompanied the great agricultural depression of the last three or four years.

The presidential address delivered by Professor Whitbeck at a dinner on the evening of December 30 dealt in part with the broad question of the scope and purpose of geography and in part with "Adjustments to Environment in South America: an Interplay of Influences."

The relation of geography to other sciences and a possible classification of its subject matter were exposed in an introduced paper by Professor C. C. Huntington of the Ohio State University. Professor Wellington D. Jones of the University of Chicago illustrated the utility of sets of critically selected lantern slides in the teaching of regional geography. Dr. John K. Wright of the American Geographical Society stressed the geographical value of the study of the history of geography. Two papers were devoted to subjects in the field of historical geography, one by Miss Mary J. Lanier of Wellesley College on "The Early Development of Boston as a Commercial Center" and one by Professor F. J. Turner, formerly of Harvard, on "Geographic Sectionalism in American History." Professor Turner illustrated by means of a striking series of maps the development within the United States of sections of more or less political homogeneity, each section being somewhat comparable to a European nation both in extent and in political and economic unity.

OBITUARY

GEORGE CARROLL CURTIS. George Carroll Curtis, America's foremost maker of geographical and geological models, died in Boston on February 2 in his 54th year.

Mr. Curtis had a most remarkable career. After graduating from Harvard he devoted two years to research work in geographic modeling under the direction of Professor W. M. Davis, while at the same time acting as an assistant in the Department of Geology and Geography at Harvard. His model of the Metropolitan District of Boston made for the Commonwealth of Massachusetts was considered so perfect that it was sent to the Paris Exposition of 1900 and received the gold medal for being the finest work of its kind produced up to that time. Curtis then went to Zurich and studied under the famous Albert Heim, producing here a model of the well known Säntis peak. In 1902 he made two models of the city of Washington for the United States Senate, one from a photographic survey of the city as it was then, the other a model on lines of proposed development. Both are in the Congressional Library.

Curtis' next great work was on geographic models of land forms for class study. Dr. Alexander Agassiz decided to have made a model of a coral island. Bora Bora, in the Society Group of the south Pacific, was selected; and Curtis went single-handed at this work, spending nearly a year at the Island making a photographic survey and many soundings (compare the account in his paper "Land Reliefs That Are True to Nature" in *Bull. Amer. Geogr. Soc.*, Vol. 43, 1911, pp. 418–427). The result was the first of the naturalistic models made in America and it is as true to nature in scale and coloring as is possible. The large model of another coral island, Funafuti, was finished later.

Curtis was a sailor as well as a model maker. In 1910 alone in his yawl he explored the fiords of Newfoundland.

In 1913 Curtis was commissioned by R. W. Sayles, Curator of the Harvard Geological Museum, to make a naturalistic model of the volcano Kilauea on the island of Hawaii. This was a much more difficult task than Bora Bora. His usual method of photographic data proved insufficient to obtain details of the lavas, and he enlisted the services of J. Fred Haworth, an amateur photographer of Pittsburgh, who undertook the making of kite pictures of the volcano. The great success of these pictures enabled Curtis to finish the Kilauea model in 1917, a tremendous piece of work covering four years of hard labor (see R. W. Sayles: A Naturalistic Model of Kilauea Volcano, Hawaii, *Geogr. Rev.*, Vol. 5, 1918, pp. 38–43). On his way home from Kilauea Curtis examined volcanic islands, including Java and Sumatra, and saw over forty active vents. He had had experience earlier in the field of active volcanism as a member of the National Geographic Society's expedition which studied the great eruption of Mt. Pelée and La Soufrière in 1902.

When stricken with his final illness he was engaged upon the construction of a great relief map of the United States.

In addition to the work cited Mr. Curtis made three bas-relief models of national interest, the first of the kind ever attempted. One is of the Yosemite, one of Niagara Falls, and one of the Grand Canyon of the Colorado River. He expected to make a new mark with this new type of model and, if he had lived, would undoubtedly have done so.

Most of the geological and geographical models made by Mr. Curtis are placed in the University Museum at Harvard, which museum thus has an unrivaled collection of masterpieces of his art. Sir John Flett, Director of the Geological Survey of Great Britain, was quoted recently as saying that the Curtis models are the finest museum exhibits he had seen in America.

Mr. Curtis wrote a number of papers on his art which have been published in various popular and scientific magazines, but it is much to be regretted that he did not write a treatise on his unexcelled technique. He was an artist, a surveyor, a geologist and geographer, and a modeler—a rare combination of talents.

R. W. Sayles

Charles Montagu Doughty. Charles Montagu Doughty, author of that "georgic of the desert," "Travels in Arabia Deserta," died January 20, 1926, at Sissinghurst, Kent, at the age of eighty-two. Doughty began his travels in Arabia when he was thirty-three and for two years wandered as a confessed Christian among the Arabs. His strong character and frank personality commanded the interest and respect of the Bedouins; but finally, unable longer to bear the stigma of entertaining a Christian, they sped him on his way, and only after many desperate adventures was he able to reach the sea at Jidda.

Doughty's notes were the basis for the first mapping of the geology and hydrography of the northwestern part of the Arabian Peninsula. The results of his two years of solitary wanderings are chronicled in "Travels in Arabia Deserta" (Cambridge, 1888; reprinted in London and New York, 1924)—a book which, during the World War twenty-six years after its publication, served as a chief source of information for the British in guiding military operations in Arabia. This monumental work is not only a primary authority on Arabian geography and Bedouin life but is coming to be recognized as a great masterpiece of literature. The Royal Geographical Society conferred the Founder's Medal upon Doughty in 1912. Recognition of his geographical work came late mainly because he never followed it up. His interests in later life were diverted into other channels, notably poetry.

GEOGRAPHICAL REVIEWS

Polar Lands and Explorers

J. Rouch. **Le Pôle Nord: Histoire des voyages arctiques.** 249 pp.; maps, ills. Ernest Flammarion, Paris, 1923. 7 fr. 50. 7½ x 5 inches.

Vilhjalmur Stefansson. **The Adventure of Wrangel Island.** With the collaboration of John Irvine Knight. xxviii and 424 pp.; maps, ills. The Macmillan Co., New York, 1925. $6.00. 9 x 6½ inches.

R. N. Rudmose Brown. **A Naturalist at the Poles: The Life, Work & Voyages of Dr. W. S. Bruce the Polar Explorer.** With five chapters by W. G. Burn Murdoch. 316 pp.; maps, ills., bibliogr., index. Seeley, Service & Co., Ltd., London, 1923. 8½ x 5½ inches.

H. R. Mill. **The Life of Sir Ernest Shackleton.** xv and 312 pp.; maps, ills., index. William Heinemann, Ltd., London, 1923. 21 s. 9 x 6 inches.

Apsley Cherry-Garrard. **The Worst Journey in the World: Antarctic 1910–1913.** Vol. 1, lxiv and 300 pp.; maps, ills.; Vol. 2, viii and pp. 301–585; map, ills., index. Constable & Co., Ltd., London, Bombay, Sydney, 1922. 9 x 6 inches.

Ever since ships could sail the seven seas Arctic and Antarctic exploration has attracted the ambitious and the venturesome and will continue to do so as long as there remains a single corner unknown. The various chapters in the long story of wresting knowledge from a defiant nature form a wonderful illustration of the endurance and tenacity of man. The several books herewith treated are interesting additions to the great library of exploration.

"Le Pôle Nord" is an excellent résumé of the operations in the Far North. It is illustrated rather roughly by half-tones from photographs by Nansen and Sverdrup, mainly, and there are several small maps, simple but clear. The volume is a companion to "Le Pôle Sud," by the same author, and he has also written a number of books on oceanography and meteorology. One map, a general map of the Arctic regions, gives the courses of several of the foremost explorers, Peary, Cagni, etc., and Parry's farthest north in 1827 but fails to note the farthest north in 1806 of William Scoresby, Senior, who then reached 81° 30′—a record that stood till Parry, on William Scoresby Junior's suggestion, made his attempt on the Pole with sledges and passed the Scoresby point by a few miles.

Nor does he mention the successful survey work of William Scoresby, Junior, on the east coast of Greenland from 75° down to 69°, a distance of some 400 miles, under the extremely difficult ice conditions that always exist along that forbidding coast. Like the majority of writers and editors of encyclopedias, he is ignorant of the difference between the work of William Scoresby and that of William Scoresby, Junior, both whalers with a scientific bent which they put to good service. The book lacks an index and is not of much service for reference.

In "The Adventure of Wrangel Island" Stefansson relates the trials and the ultimate disaster attending his valiant effort to hold Wrangel Island for the British on the authority of discovery and occupation. No other nation except the United States possessed any claim on these grounds.

Believing that "the world is at the dawn of a revolution in transportation ideas" and that the development of air navigation will render Wrangel Island a necessary

base for British air craft, he and four others organized the expedition to occupy it under the British flag till the government could be persuaded of the importance of the enterprise and sanction it. It happened that he was unable to convince either the Canadian or the British government, and the aid he counted on dwindled to nothing till he found himself in a costly predicament. Then the first supply ship he sent to the island failed to reach it. The following year another got through only to discover that three of the men had vanished, the fourth lay dead, and the little Eskimo sewing woman and a cat were the only living objects remaining.

A party of Eskimos that had been brought were left on the island under the direction of an American trapper, Charles Wells, in order that a business might be started in furs and other products of the North. Stefansson sold all his claims and rights to Lomen Brothers of Nome, and it was proposed now to establish the United States' rights to the island. One day a Russian ship, the *Red October* sailed in, confiscated everything, and carried the Eskimos and Wells to Vladivostok where the latter died of exposure.

The diary of Lorne Knight, which was found in his hut, forms the basis of this volume; but there is much else in the way of historical data that is important. There are numerous illustrations from photographs and a map of the northern hemisphere showing the advantageous position of Wrangel Island.

"A Naturalist at the Poles" is a volume linking both ends of the world and tying them together with the equator, for the subject of it, Dr. W. S. Bruce, was active all over the face of the earth—one of the foremost explorers, oceanographers, and scientific observers of our time. He was a man modest and efficient and willing to allow his work to speak for itself: the world at large knows little about him. The author of this volume served with Bruce on several voyages, shared his work at home, and for some twenty years was in his confidence. For the earlier years, with which the author was not familiar, he obtained the five chapters from W. G. Burn Murdoch, who knew Bruce equally well in that period. The result is an excellent history of Bruce's work. The illustrations are from fine photographs and are well printed. There are two first-class maps, one of the North, the other of the South Polar regions. Some explorers' routes are given, among them Parry's farthest north; but Scoresby's earlier north is again lacking. There is an illuminating chapter on Spitsbergen, a region on which the author is a first authority. An appendix furnishes a list of Bruce's publications and a chronological list of his voyages. An excellent index renders the book easy for reference.

"The Life of Sir Ernest Shackleton" is made up from every available source—records, diaries, correspondence, and frequent consultation with Lady Shackleton—and is authoritative and definitive.

Shackleton, it need hardly be said, was a real explorer, full of resourcefulness and determination; yet it has appeared strange that when the *Endurance* in 1915 was beset very near the shore of Coates Land no effort was made to relay supplies to land and strike out across the unknown. The ship was lost later, and the lot of the party would have been no worse on the land than it was drifting and on Elephant Island. The voyage in a small boat, 22 feet long, from Elephant Island to South Georgia across tempestuous seas was one of the thrilling episodes of the expedition. Shackleton's own description of that trip in his "South" is one of the classics of the sea and should be printed separately. An epilogue gives a detailed estimate of Shackleton's character. There are four maps in the text, many excellent half-tones, and a good index.

"The Worst Journey in the World" is Mr. Cherry-Garrard's own account of the last Scott expedition to attain the South Pole. It is a frank and careful work, describing the details of the expedition admirably, and incidentally once more revealing the superb pluck and determination of Captain Scott and the devotion which animated the entire party.

One of the striking features is the description of a five weeks' winter excursion, a terrible journey, solely for the purpose of securing eggs and embryos of the emperor penguin. After their almost incredible effort they got back with three eggs!

They were disturbed when they discovered Amundsen was "cutting in" on the South Polar job. The author speaks well of Amundsen but remarks: "For the moment, let it be confessed, we all underrated Amundsen and could not shake off the feeling that he had stolen a march on us."

Mr. Garrard's admiration for Scott is without limit. "Scott," he declares, "will go down to history as the Englishman who conquered the South Pole and who died as fine a death as any man has the honour to die."

There are numerous extracts from "Scott's Last Expedition" and from Priestley's and his own diary. All the illustrations are good and some are beautiful. The latter are reproductions of water colors by Dr. E. A. Wilson, who was an artist of the first rank as well as a skilled scientist.

FREDERICK S. DELLENBAUGH

THE WEST INDIES

W. P. WOODRING, JOHN S. BROWN, AND W. S. BURBANK. **Geology of the Republic of Haiti.** 631 pp.; maps, diagrs., ills., bibliogr., index. Geol. Survey of the Republic of Haiti, Port-au-Prince, 1924. 9 x 6 inches.

T. W. VAUGHAN, WYTHE COOKE, D. D. CONDIT, C. P. ROSS, W. P. WOODRING, AND F. C. CALKINS. **A Geological Reconnaissance of the Dominican Republic.** 268 pp.; maps, ills., bibliogr., index. *Geol. Survey of the Dominican Republic Memoirs*, Vol. 1, Washington, 1921. 10 x 7 inches.

Topographic Map of the Dominican Republic, 1:100,000, 4 complete sheets, 4 partial sheets. Surveyed by the United States Geological Survey in coöperation with the Secretaria de Fometo y Communicaciones, of the Dominican Republic, 1919–20.

Carte de la République d'Haiti. Dressée par le Service des Levés Topographiques d'Haiti sous la direction du U. S. Geological Survey . . . d'après des photographies prises d'aeroplane et contrôlées par des triangulations, 1923, 14 sheets, 1:100,000. Also in one sheet on scale of 1:400,000.

Many notable contributions to the knowledge of the geology and geography of Haiti and the Dominican Republic have been made in the past 75 years. Most of the studies carried on previous to the occupation of the two republics by the United States fall into two classes—studies of areas which, although detailed in themselves, give no adequate conception of the physical character of the island as a whole and very general reconnaissances which are not sufficiently detailed to be of any great economic value. Most noteworthy among these studies are Gabb's geological and topographical reconnaissance of the Dominican Republic in the early seventies and Tippenhauer's geological and topographical surveys of sections of Haiti in the last decade of the past century. Gabb's topographical map, although highly inaccurate in many places, has been used up to the present time as the basis for all general maps of the Dominican Republic. Subsequent studies have shown that, whereas Tippenhauer's geological interpretations are frequently wrong in detail, the general character of his work was of a high degree of excellence; while those who have followed his various routes report that his topographical surveys are of an "uncanny accuracy."

Nevertheless the combined work of Gabb and Tippenhauer and others does not furnish sufficient detailed information to make it possible to compile an accurate geological map of the island or to afford accurate knowledge of mineral resources.

In accordance, therefore, with the desire of the United States, as expressed in the treaties with the Dominican Republic and Haiti, to aid in the proper and efficient development of the agricultural, mineral, and commercial resources of the two countries, a geological reconnaissance of the Dominican Republic was carried out in 1919 by a personnel furnished by the United States Geological Survey, and a similar reconnaissance of Haiti in 1920 and 1921. The reports of these two reconnaissances are contained in the two volumes described above. In addition to the remarkably detailed reports on the geology and physiography of the two countries, accompanied by many profiles, maps, photographs, and rock analyses, each volume contains an important bibliography and a chapter on the geography of the respective countries. The two volumes constitute a standard work on the geology and geography of the island that has no counterpart elsewhere in Latin America.

Coincident with the geological reconnaissances a start was made, also under personnel furnished by the United States Geological Survey, on an accurate map of the two republics. In 1919 and 1920 a detailed topographic survey based on precise triangulation was carried out in the Dominican Republic over an area of approximately 4500 square miles (about ⅛ of the whole country) north and west of Santo Domingo. The survey has been published on the scale of 1:100,000 in four complete sheets, each 30 minutes of latitude by 30 minutes of longitude, and four partial sheets. It is understood that this map covers all the survey so far completed. Now that the American forces have been withdrawn from the republic, it is probable that there is no immediate prospect for the completion of the survey. In Haiti it is understood that the topographic survey has not advanced beyond a triangulation of the coast and the plains of Artibonite and Cul-de-Sac. Naval airplanes photographed the whole coast of the island and many of the more important populated regions. In Haiti these photographs have been adjusted to the Haitian triangulation, and a map has been drawn from the mosaic. This map covers the entire coast of Haiti and the Artibonite and Cul-de-Sac plains. Drainage and roads are shown on the two plains and along the coast. No contours or spot heights are given. The photographs of the Dominican Republic have not been compiled into a map because of the lack of a precise triangulation upon which to adjust them.

J. W. McGUIRE. **Geographic Dictionary of the Virgin Islands of the United States.** iii and 211 pp.; bibliogr. *U. S. Coast and Geodetic Survey Special Publ. No. 103*, Washington, 1925. 25 cents. 9 x 6 inches.

Yes: $295 an acre was certainly high for the smallest land purchase the United States ever made. Alaska at 2 cents an acre was a better bargain. But everything connected with the Panama Canal came high, as military things always do.

The gazetteer is a mine of valuable information and interesting mainly, of course, for the three chief islands, St. Croix, St. Thomas, and St. John. For instance the *plantage* is an "estate" of 2000 by 3000 Danish feet, or 146 English acres, in which the islands were granted out to colonists, the usual payment reported being an annual rental of one turkey to the governor.

There is a brief account of the islands, their history and cartography, and then the work occupies itself with the Dictionary. As it is a work of reference there is no better way to test it than to look up something in it about the islands. The Department of Commerce does not perhaps include man in its concept of geography, but the reviewer, who does, happens to be interested in the density of population on oceanic islands. It often runs high, especially in the West Indies. How is it with the Virgin Islands of the United States? What is the density of population on the various islands?

On page 22 we are told that "a census taken by the United States [in 1917–18] showed the total population of the 6 inhabited islands, viz. St. Thomas, Hassel Island, Water Island, Lovango Cay, St. John, St. Croix, and Protestant Cay, to be

26,051, of whom 1922 (7⅜ per cent) were white. Density, 196 persons to 1 square mile." A total area of 132.92 square miles is given. But the *seven* (not 6) islands described as inhabited have populations and areas given in the separate items of the Dictionary under their names of 26,071 people on 129.2 square miles. No population figures are given for Hassel Island, Water Island, or Protestant Cay. Probably they are included in the figures for the three main islands. Indeed, as the figures for St. Thomas (10,191 on 27.12 square miles), St. Croix (14,901 on 81.93 square miles), and St. John (959 on 19.20 square miles) sum up 26,051 on 128.25 square miles, it is probable that the 20 inhabitants reported for Lovango Cay are included in the figures given for St. John. The real figures will therefore be 26,051 inhabitants on 129.2 square miles, including the areas of all seven of the inhabited islands, giving 202 people per square mile. St. Thomas has 376 square miles without the city (91), St. Croix 182—not 200 as given in the Dictionary—and 89 outside of Christiansted and Frederiksted, and St. John 50. Lovango Cay has 0.184 square miles, 20 people, and a density of 109 people to the mile. We do not learn the densities for the remaining three islands. Probably the population on them is not sufficient to make any appreciable difference in the population density on the larger islands where, I assume, they are included.

The reviewer does not notice any information on the rather practical point of the pronunciation of St. Croix. When he was there in 1895 it seemed universal to call it St. *Cry*, to rhyme with *dry*.

Much the greater part of the book consists of synonyms for points on the various charts of the islands extant.

MARK JEFFERSON

GEORGE MANINGTON. **The West Indies, With British Guiana and British Honduras.** xvi and 304 pp.; map, ills., index. Charles Scribner's Sons, New York, 1926. $4.00. 9 x 6 inches.

The greater part of the book is a traveler's description of things he saw or did not see in various islands of the West Indies. In this part there is little if anything new. Nor has the description any particular merit. The author makes little attempt to interpret what he sees. In this particular, the work is a disappointment. Such a book may satisfy the casual reader, but not the geographer. A little touch of humor or sentiment would enliven the rather colorless treatment.

The latter part of the book, Chapters 16 to 25, is more interesting. These chapters deal with the peoples of the islands and give a little of the history and politics. The reader is frequently puzzled over the things which are or are not given emphasis. For example, it might be expected that the great sugar industry that has developed in Porto Rico would receive some emphasis, since it nearly dominates the economic life of the island and supplies 50 to 60 millions of dollars to the annual exports of the country. Yet it is barely mentioned. The surprisingly large per capita commerce of Cuba is unnoted, while incidents or facts of small moment are recorded. The "extensive oil fields" of Cuba are mentioned but, of course, do not exist so far as is known.

In dealing with political and racial matters an excellent spirit is shown. All references to the part the United States is playing in the Caribbean region are kindly.

R. H. WHITBECK

THE INDIANS OF CALIFORNIA

A. L. KROEBER. **Handbook of the Indians of California.** xviii and 995 pp.; maps, diagr., ills., bibliogr., indexes. *Bur. of Amer. Ethnology Bull. 78*, Smithsonian Instn., Washington, 1925. 9 x 6 inches.

At last there has appeared a work on the aborigines of a single state which sets so high a standard for a work of its character that it is unlikely to be surpassed in the

near future. Several factors contribute to make Professor Kroeber's "Handbook" an outstanding achievement. In the first place the author combines extensive field experience with marked literary gifts as well as scientific acumen. In the second place the subject matter is exceedingly varied. No other state in the Union reveals so culturally and linguistically diverse a primitive population as that of Indian California. Thus the theme is of wide appeal.

The culture of central California was peculiar to and most characteristic of the state. The southland presented a modified form of the culture of the great Southwest; while northwestern California formed the southern extremity of the north Pacific coast culture area. With the Southwest, southern California had in common pottery, sand paintings, and many other features. With the north Pacific coast the northwestern part of the state shared woodworking, wealth concepts, slavery, and a host of other features.

The author's field experience with the Californian Indians extended over seventeen years. Most notable as pleasing accounts of primitive peoples with whom he has spent much time are his chapters on the Yurok of northwestern California, the Yokuts of central California, and the Mohave of the Colorado River in southern California. No portion of the state is neglected, for the author has assembled data from all available sources. A fine series of carefully prepared maps relieves the reader of all need of drawing upon his memory or the atlas. Moreover, the volume is profusely illustrated with photographs and sketches.

Equally as thorough as the geographic treatment is the author's cultural treatment. Archeology as well as ethnology is fully discussed. Society and religion receive their full share along with the arts and industries. Discussion of these three departments of culture is always preceded, however, by a careful exposition of the relation of each group to its geographic setting, the author rightly regarding this as a first duty.

Throughout the volume Professor Kroeber carefully differentiates, so far as present knowledge allows, between that which is inherited and that which is acquired. The varied geographic environments of California are not regarded as the sources of the three great cultures of the state but merely as the sources of raw materials which these cultures have utilized. That the cultures are the product of their physical environments is to the author unthinkable, for he is of the firm opinion that social environment, not geographic environment, begets culture.

The Bureau of American Ethnology is to be congratulated upon the advent of this survey. It is to be hoped that it will be followed by similar volumes for the other states of the Union. Such works have not only a high scientific value but also a wide popular appeal.

E. W. Gifford

Physical Geography of Georgia

Laurence LaForge, Wythe Cooke, Arthur Keith, and M. R. Campbell. **Physical Geography of Georgia.** With an introduction by S. W. McCallie. ix and 189 pp.; maps, diagrs., ills., index. *Geol. Survey of Georgia, Bull. No. 42*, Atlanta, 1925. 10 x 7 inches.

Five geographical provinces make up the state of Georgia, all of them extending far to the northeast into the adjacent states. These provinces, Coastal Plain, Piedmont Upland, Appalachian Mountains, Appalachian Valley, and Appalachian Plateau, are each made up of a number of divisions which may in turn be further subdivided. Thus, by working from the larger area to the smallest distinctive unit and by a clear, easily apprehended classification of these units, the authors proceed to describe the entire state in untechnical language quite suited to the layman's use for which the book is intended. Like similar volumes published by other states,

its widest use will be in the schools and perhaps largely by teachers not especially trained in geology or physiography. For this purpose it is admirable. This function of the book, to some extent, has forced the authors to the use of empirical descriptions rather than the explanatory method of presentation. As a consequence there seems to be a great prolixity of detail, not always tied together by causal relationships; but at intervals through the text explanations of the origins of the features are introduced. This is essentially an inductive treatment, a type of presentation which always holds the inquisitive reader in suspense.

The reason for the failure to suggest the explanation of several striking features is not thoroughly clear to the reviewer unless it be the too technical character of these explanations. For instance, not a word is said about the origin of Tallulah Falls, nor is reference made to Johnson's work on that region, although the falls are mentioned several times. No constructive suggestion is made, either, concerning the origin of the Blue Ridge. The coastal terraces, however, are well described from the standpoint of their origin.

Among the outstanding excellencies of the book are the splendid full-page contour maps in black printed by the United States Geological Survey, the numerous good and well chosen photographs, and the many references to human affairs and their control by the physical environment. A volume like this should be an incentive to others to issue similar bulletins. It is unlikely, however, that many other states could muster so distinguished a group of able men intimately acquainted with the local details of their area.

A. K. Lobeck

A Study in American Physiography

Douglas Johnson. **The New England-Acadian Shoreline.** xx and 608 pp.; maps, diagrs., ills., bibliogr., indexes. (Studies of American Physiography.) John Wiley & Sons, Inc., New York; Chapman & Hall, Ltd., London, 1925. $8.50. 9 x 6 inches.

Physiography becomes more scientific in its results as it employs quantitative methods and critically analyzes special cases. From this standpoint alone Professor Johnson's second volume, in a series of three projected volumes on the Atlantic shore line, is highly important. It is focused upon the special features found in the shore zone, for here the physical relations are more complicated than in any other part of the surface of the earth. The complication is due in part to the fact that the strand is the meeting place of two different types of erosive agencies and that it divides sea floor and land surface (each a distinctive unit) with its own peculiar modes of development. In addition, the outline of the coast itself is subject to certain laws of development which, while dependent upon the processes of sea and land, have peculiar modes of expression. The forms of the coast pass through an independent cycle of their own.

It follows from this that Professor Johnson's book has a great deal to do with the physiography of the whole New England-Acadian region; just as it includes the development of the forms of the sea floor, especially in the region known as the Gulf of Maine, where an earlier land surface has been depressed below sea level without having its characteristic coastal plain topography destroyed in the process. By concentrating upon the shore zone, Professor Johnson is able to develop his ideas in a systematic and analytical fashion that may be said to represent the high-water mark of the so-called Davis method. If one were to criticize at all so excellent a presentation it would be to express a doubt as to whether the elaborate development of the argument from place to place is justified in view of the limited number or the limiting character of the facts. Physical forms in their infinite variety are not capable of that ultimate analysis which is possible in certain branches of

physics and chemistry, and it is possible to overload the available facts with too heavy a superstructure of theoretical considerations.

Professor Johnson believes that the New England-Acadian coast gradually subsided during its later history and that that subsidence culminated possibly three thousand to five thousand years ago. In his view the chief features of the original shore line may still be seen or may easily be restored, marked as they are by a close dependence upon geologic structure. Marine agencies have modified the original coast only to a moderate extent. In New Brunswick and Prince Edward Island, as well as on the shores of the Narragansett lowland, the shore features are in a later stage of development, but they are still youthful. One of the most important contributions to the book is the analysis of supposed elevated shore lines and the evidence of relative change of level of land and sea during the last few thousand years. Alleged evidences of former submergence are shown to be capable of quite satisfactory explanation on other grounds. In his detailed analysis of these features from point to point along hundreds of miles of coast, Professor Johnson has made a contribution of the first order. The older arguments are now seen to be quite without real scientific foundation. Professor Johnson describes the so-called Fundian fault as one of the important lines of dislocation in eastern North America and recommends detailed study of it because of its possible relation to earthquakes in New England. Equally important is his suggestion that the form of partly enclosed water bodies open to the sea should be determined by a more detailed study of the water level during different phases of the tide, for only by this means can the next step be taken in the scientific study of the meaning of shore lines in such semi-protected situations. Further critical value attaches to such data for they will enable us at some time in the future to compare readings taken during the interval and thus by instrumental means *prove* or *disprove* the stability of the land during the period in question.

Professor Johnson is to be commended for the clear and precise manner in which all of his observations are presented and upon the fullness of his treatment. With the completion of his projected three volumes he will have brought to an advanced stage one of the most important studies in American physiography. His first volume on "Shore Processes and Shoreline Development" has been recognized as a work of high distinction. It is also to be noted that the present book was awarded the A. Cressy-Morrison prize of the New York Academy of Sciences for 1924.

A Population Density Map of European Russia

Benjamin Semenov-Tian-Shansky, edit. **Dazimetricheskaya Karta Evropeiskoi Rossii (Carte dasymétrique de la Russie d'Europe)**, 1:420,000. Inst. d'Études "Le Sol et le Sous-Sol," Leningrad, 1923—.

In undertaking this population density map the "Research Institute of Soil and Subsoil," founded in 1918 under the direction of P. Palchinsky, will place all geographers in its debt. It offers the first opportunity for detailed study of the distribution of population on the vast plains of eastern Europe from the Arctic to the subtropical zone. The plan calls for 145 sheets, each measuring (printed surface) 22 x 25 inches, of which 122 are within the boundaries of the Soviet Union. During 1922–1925 28 sheets were published and 16 were in preparation. Each sheet is accompanied by a pamphlet with résumé in French. There is a summary history of the map by its compiler Benjamin Semenov-Tian-Shansky, son of the well known Russian geographer, Peter Petrovich Semenov-Tian-Shansky.

The sheets published cover the area from the western boundary of the Soviet Union along the line Leningrad-Odessa and eastward to the line defined by Archangel, Nijni Novgorod, and Rostov. Three Ural sheets are also published.

The sheets northeast of the upper Volga show the immense uninhabited areas of northern Russia and its very few patches of cultivated land along the most impor-

tant rivers and lakes. The central sheets within the triangle between Nijni Novgorod, Leningrad, and Kiev show the main part of temperate Russia, in climate and vegetation more comparable with southern Sweden and east-central Europe. Vast agricultural areas separated by narrower forest belts are characteristic for this region, as well as many towns with, at least before the great war, rather important manufacturing plants, textile and metal works. The nature of prevailing industries other than agriculture is noted on the map but not shown graphically. Sites of mineral resources are shown by symbols. The southern sheets show settlements within the steppe region, consisting of rows of large villages along all streams which provide water for men and animals during the hot summers.

The method employed in constructing the map is described by G. F. Malyavkin. He points out the inadequacy of the method of showing population density by which the surfaces of whole counties (*uyezdi*) are colored according to their mean population density. In reality population is concentrated along rivers and shores, along lines of communication, around points of commercial or political importance, and on agricultural areas. History shows that the same places have been repeatedly recolonized in Russia.

In the first instance the map distinguishes the uninhabited and sparsely populated areas from those of denser population. The density of 10 to the square verst (22.5 to the square mile) was chosen as the lower limit of the cultivated area, or limit of areally continuous population. The limit was plotted by drawing circles with a radius of one verst about all populated places named on the standard 10-verst map (1:420,000) of Russia and by smoothing the coalescing arcs on the outer margins of the areas so delimited. The selection of a radius of one verst is justified by the fact that the fields belonging to Russian villages are usually within one verst from the village center. Small groups of houses may be omitted; but where villages lie in lines they are included within the smoother curve, even if separated by distances of two or three versts. It is admitted that the radius and the modifications of the curves are somewhat arbitrary, but, since the method is used uniformly all over Russia, it is hoped the results will at least be comparable.

In the opinion of the present writer such a method is justified in two cases: (1) when used as a generalization to express as a single large area a number of small areas of similar character, the maximum distance between them being the radius of the curve, and (2) when the real boundary lines of the areas in question are not known in detail. The first was the case in the delimitation of the uninhabited area of northern Sweden on the writer's population map (see "A Map of the Distribution of Population in Sweden: Method of Preparation and General Results," *Geogr. Rev.*, Vol. 12, 1922, pp. 72–83), where arcs of 10 kilometers radius were used. The second was the case in the selection of limits for the more densely populated parts of Russia on Semenov's map. In Sweden the latter application of the method was unnecessary, since there are official maps which permit the geographer to determine the real limits of inhabited and cultivated land.

The population figures used are based on the only complete census of Russia, that of 1897, which enumerated all towns and villages down to 500 inhabitants separately, smaller ones being included in the totals for administrative areas and being known only by location and name on the 10-verst map. This census, however, was considered antiquated, and a laborious but certainly less reliable modernization of the population figures was made by computing figures for 1915, based on data for the natural increase. A new census is planned, to be made in 1926. One must regret the lost opportunity of obtaining two density maps, for the years 1897 and 1926, based on exact figures instead of one approximate map for 1915.

Degrees of density on a regularly ascending scale are shown on the map in color as follows: three yellow tones, densities of 0–10, 10–20, and 20–30 inhabitants per square verst; three orange tones, densities up to 40, 50, and 60; three carmine tones,

densities to 70, 80, and 90; and five violet tones, densities to 100, 200, 500, 1000, and over 1000 per square verst. Every isolated populated area is marked by a number and by its average density figure, while villages and towns with over 500 inhabitants in 1897 are shown by a symbol of arbitrary size. The symbols for the villages are rather insignificant, while those for the cities are quite conspicuous, though many of the latter have a smaller number of inhabitants (Pinega, sheet 67, 1800) than large villages (Bereznegovati, sheet 33, 9400). As all cities, towns, and larger villages have their population figures on the map, it should have been an easy task to make them all visible by means of a rational system of symbols, whether regular surfaces or shaded bodies.

Since the population of places with less than 500 inhabitants in 1897 is not known, all smaller places named on the 10-verst map were counted for each *uyezd;* and the remainder of the population of the *uyezd*, after subtracting the population of the known larger places, was divided among the smaller. Thus the value found is the mean size within each *uyezd*, and it becomes possible to estimate approximately the population of every individual densely populated area, even though it is divided between two *uyezdi*. It becomes further possible to divide this approximate population figure by the approximate area within the circular line around cultivated land and to determine the mean density of population per square verst of the areas of the dasymetric map.

Evidently the values for density arrived at in this manner are not particularly exact. A dot map would have offered two advantages: (1) it would avoid the inaccuracy of expression in the insufficiently known areas, and (2) it would make the exact population figures of 1897 directly visible, for example by means of dots of equal value for every 500 inhabitants in towns and cities, in large and small villages, as well as on scattered farms all over the country.

A first attempt to use the population density map as a base for studies of the human geography of Russia was made by Semenov in 1924 in a pamphlet in Russian with a map of central Russia around Moscow on a scale of 1:3,570,000 and a résumé in French, in which he shortly describes 33 areas of comparatively dense population and 22 intervening nearly uninhabited areas within this agricultural and manufacturing region.

STEN DE GEER

THE GEOGRAPHY OF EUROPE

ALFRED HETTNER. **Grundzüge der Länderkunde.** Vol. 1, **Europa.** 2nd edit. revised. viii and 373 pp.; maps, diagrs., index. Vol. 2, **Die aussereuropäischen Erdteile.** 1st and 2nd edit. vi and 451 pp.; maps, diagrs., index. B. G. Teubner, Leipzig and Berlin, 1923, 1924. 9 x 6½ inches.

Those who have known and used Hettner's "Länderkunde," Vol. 1, since 1909, will welcome the completion of the whole work now before us. This present edition is a combination of the third edition of Vol. 1 (the second appeared in 1921), with the first of Vol. 2. The volumes are of handy size for reference and class use, Vol. 1 being reduced to about half its original size. Thus it has become practically a new book, but details only have been sacrificed in the process of reduction. At the beginning a new chapter has been inserted giving an introduction into the history of discovery and exploration of the European countries. To the natural divisions has been added a chapter on the northern islands (Iceland, Faeroes, Jan Mayen, Spitsbergen, Franz Josef Land, Novaya Zemlya). In Central Europe the chapters devoted to the comparison between the natural geographical, ethnical, and linguistic boundaries with the actual political divisions deserve the greatest attention of the reader who is not a specialist in the history of these countries. They present a scientific and sober examination of the changes in Central Europe resulting from the war, and valuable diagrams are given in illustration.

Volume 2 contains the geography of the extra-European countries. The author strongly emphasizes the arbitrary character of the division into continents. While we cannot dispense with it for reasons of convenience, modern geography cannot use it as a basis for scientific research. Climate, vegetation, civilization, etc. are not dependent on continental divisions, and it is only by forming subdivisions of similar physiographic and geologic nature that these phenomena can be satisfactorily explained. In the description of the individual continents, of course, essentials only can be treated in the small space available, and much "interesting" detail must be omitted; but the author prefectly succeeds in giving a well-rounded monograph of each of the continents in spite of these restrictions. The qualities which characterized the first volume from its very appearance, careful selection of the material, clear presentation of the problems, a large number of supplementary diagrams, etc., are fully in evidence also in the second volume. As a brief yet thoroughly scientific introduction into the vast field of geography, as well as for purposes of reference, the work ought to be found in every library where German is understood.

MARTHA KRUG GENTHE

THE CLIMATE OF GREECE

E. G. MARIOLOPOULOS. **Étude sur le climat de la Grèce: Précipitation; stabilité du climat depuis les temps historiques.** 66 pp.; maps, bibliogr. Les Presses Universitaires de France, Paris, 1925. 10 x 7 inches.

Dr. E. G. Mariolopoulos discusses the two main problems of precipitation and change in the climate of Greece since the beginning of history. He puts particular stress upon the latter and, contrary to the hypothesis put forth by Huntington, maintains that there has been no noteworthy change. He has carefully studied all references to climate in ancient literature and, furthermore, has compared the crops, especially the cereals mentioned by early writers, with those of the present day. The conclusions reached do not embrace northern Greece, that is Epirus, Macedonia, and Thrace: long under Turkish domination these furnish no consistent and long-period records.

Distribution of rainfall is considered for the seasons and the year. Rainfall is noticeably heaviest on the west coast—about 1000 millimeters (25 inches) with the maximum at Corfu, 1217 millimeters. The months of most frequent and heaviest rain are November, December, and January; about 45 per cent of the total rainfall for the year falling within that period. The duration of the dry period differs with locality. At Corfu there is a mean duration of 53 days; at Zante, 107 days; at Athens, four months. In the islands of the Aegean as well as in the countries to the south the dry interval is even longer.

In addition to the geographical distribution of rain, character of rainfall, annual variability, snow, hail, and thunderstorms are discussed. The author quotes Eginitis on the variability of the rainfall at Athens. In 1883 there was a rainfall of 847 millimeters, while in 1898 the amount was 155 millimeters. These are not extreme cases, and doubtless similar cases can be found in ancient history. It probably was during such a period of little rainfall that the Athenians, according to Pausanias, erected on the Acropolis a statue representing Earth supplicating Jupiter to send rain. Doubtless other statues erected to an ombrometric Jupiter in different parts of Greece had a similar origin. It would seem that a period of four or six dry years is generally followed by one or two wet years.

ALEXANDER MCADIE

THROUGH EASTERN TIBET

WILHELM FILCHNER. **Quer durch Ost-Tibet.** x and 195 pp.; maps, ills. E. S. Mittler & Son, Berlin, 1925. 10 x 7 inches.

This book records an expedition made in 1903–1904, through a then almost unknown part of northeast Tibet, extending between about latitude 32° 45′–36° 30′

N. and longitude 97° 30′–103° E. Filchner was accompanied by Dr. Tafel, of Württemberg, and nine Chinese. Their transport animals were yaks and horses.

Starting from near Koko-Nor, Filchner traveled southwest over barren steppes, in places 4000 meters in altitude, to Oring-Nor whence flows the main source of the Hwang Ho, called Machu by the Tibetans. Thence he traveled east and southeast along the upper reaches of the Hwang Ho through mountainous country, crossing one pass with an altitude of 5100 meters.

The first Tibetans Filchner met were friendly and pleasant: but the Ngolok tribe suspecting that Filchner and Tafel were Europeans proposed to kill them. After this, the journey became a wild adventure. They were frequently attacked, but fear of magic powers kept the Tibetans from closing in. On such occasions the Chinese escort merely yelled and fired in the air. In one Ngolok encampment the travelers were actually taken prisoners. They saved themselves by pretending they were Mohammedans from Kashgar, and in this they were backed by two genuine Mohammedans who happened to be there trading with the Tibetans. They finally reached Sung-pan-ting in China, nearly starved and in rags. Despite the dangers and hardships, however, Filchner says he would gladly go once more to Central Asia.

EDWIN SWIFT BALCH

A STUDY OF LAKES

LÉON W. COLLET. **Les lacs: Leur mode de formation, leurs eaux, leur destin; éléments d'hydro-géologie.** xi and 320 pp.; maps, diagrs., ills., bibliogrs., index. Gaston Doin, Paris, 1925. 35 fr. 9½ x 6½ inches.

In the preface the author states that this book is addressed especially to geologists, engineers, and geographers; many features are included which are interesting to limnologists also. Collet treats lakes from a standpoint so different from that of Halbfass in his recent "Grundzüge einer vergleichenden Seenkunde" that the two books supplement each other rather than overlap to any great extent.

In the first part of the book, the mode of formation, the author discusses lake basins formed by glacial erosion, barrier basins, crater lakes, basins due to tectonic agencies, and solution basins. Examples of the different kinds are given, and their more salient features are considered. The majority of the examples are Swiss lakes, and 28 excellent plates are used to illustrate points presented in the text.

The second part of the book deals with the annual variations in lake levels and the temperature, the chemical composition, and the color of lake waters. The annual variations in the levels of a number of lakes situated in the Alps are shown in graphic as well as tabular form. The seasonal changes in the temperature of the water and the resultant inverse and direct stratifications of lake waters during the winter and summer seasons are discussed at some length. The unusual thermal conditions in Ritom Lake are presented in considerable detail. In this lake the lower water is more strongly mineralized than the upper, so that convection currents do not play their usual rôle in mixing the upper and lower strata; as a result the temperature of the lower water is substantially the same at all seasons of the year.

In the chapter dealing with the chemical composition, analyses are given for a considerable number of lakes, including both salt and fresh-water lakes. The salts held in solution by the water of a lake are a function of the composition of the rocks of the drainage basin. Climate has an effect upon the quantity of salts in solution.

The color of lakes is affected by several factors, among which are living organisms, particles held in suspension, and substances in solution. The Forel-Ule scale is used for indicating the color of different lakes.

The third part deals with the destiny of lakes. The erosion of the shores and the silt and coarser material brought into lakes by their affluents gradually fill their basins. The coarser material is deposited in deltas, and the silt is deposited as a

sediment on the bottom of the lake. The rate of deposition and the chemical composition of this sediment are given for a number of lakes. The deltas formed by streams entering some of the European lakes have been used for the purpose of estimating the period of time that has elapsed since the last glacial epoch.

In the final chapter, lakes are considered from the standpoint of their utilization in the development of hydro-electric power.

C. JUDAY

SEA LEVEL IN RELATION TO ATMOSPHERIC PRESSURE

ALFRED WEGENER. **Luftdruck und Mittelwasser am Danmarks-Havn.** Diagrs. *Annal. der Hydrogr. und Marit. Meteorol.*, Hamburg, Vol. 52, 1924, pp. 32–38.

A. T. DOODSON. **Meteorological Perturbations of Sea-Level and Tides.** 24 pp.; Diagrs. *Monthly Notices Royal Astronom. Soc., Geophys. Suppl.*, Vol. 1, No. 4, 1924.

SINKITI OGURA. **Effect of Atmospheric Pressure on Sea-Level in the Western Part of the North Pacific Ocean.** Diagrs. *Japanese Journ. of Astronomy and Geophysics*, Tokyo, Vol. 2, 1925, pp. 209–231.

In the determination of mean sea level at any point on the coast the disturbing effects of strictly periodic forces can generally be eliminated without difficulty. Thus the rise and fall of the sea due to the tide presents little difficulty in the problems of mean sea level determination. But the fluctuations of sea level due to variations in wind and in barometric pressure introduce factors that are difficult to evaluate. It is with the latter problem, and more especially with the fluctuations in sea level arising from variations in barometric pressure, that the three publications under review are concerned.

As a first approximation any arm of the sea may be regarded as constituting a huge inverted water barometer. Hence when the barometric pressure over this arm of the sea rises the surface of the water will be lowered, while with a decrease in barometric pressure the surface of the water will rise. And, since mercury is approximately thirteen times as heavy as sea water, it follows that a change in barometric pressure of one inch should be reflected by a change of a little more than one foot in the level of the sea; more precisely, the ratio of change of sea level to change of barometer is 13.2.

Prof. Wegener's paper is a study of the relation of sea level to barometric pressure at Danmarks-Havn near Cape Bismarck on the northeast coast of Greenland (latitude 76° 45′ N.). While wintering there he had noted that during snowstorms the water frequently rose through the tide cracks and spread over the ice anchored to the shore. At that time he ascribed this to the weight of the new snow on the ice together with the higher temperature. Later it occurred to him that the rise of sea level might be an accompaniment of the falling barometer, and in this paper he discusses the barometric and tide records obtained for the period January 21–March 1, 1907. On plotting the curves of sea level and barometric pressure for the period it appears immediately that the two curves follow each other closely, the sea level curve being about six and a half hours behind the pressure curve. Here, therefore, the variation in sea level is dependent principally on the variation in barometric pressure, other factors playing but a minor rôle. This is in contrast to conditions in lower latitudes where the effect of barometric pressure is secondary to that of the wind. As Wegener remarks, the atmospheric pressure at Danmarks-Havn can be determined directly from the height of sea level with satisfactory approximation. The relegation of the wind to a secondary place as a factor in sea level variation in the polar regions is obviously to be ascribed to the fact that the ice cover over the sea effectually shields the water from the effect of the wind.

The methods usually employed in making tide observations in polar regions frequently introduce errors in the observations. Wegener makes a critical examination of the tidal data and concludes that variations in atmospheric pressure at Danmarks-Havn are reflected by inverse changes in sea level 11 to 12 times as large. This is somewhat less than the theoretical ratio of 13.2; but, as the author points out, the latter ratio corresponds to a stationary condition while variations in atmospheric pressure frequently occur so rapidly that sea level has insufficient time to adjust itself.

Dr. Doodson's paper is a comprehensive mathematical investigation of the perturbations in sea level at a number of stations in the British Isles but principally at Liverpool and at Newlyn. Instead of using the local barometric pressure alone he employs pressure gradients, a method introduced by Witting in 1918. This method in effect introduces correction factors for the wind. Doodson discusses the influence of geographical situation and concludes that purely local configuration of coast line plays a minor rôle. Thus he finds that on the east coast of Britain the winds that raise sea level most are those from the west, that is, the winds blowing away from the land.

Doodson's results show that the use of barometric gradients brings the value of the ratio sea level change to pressure change closer to its theoretical value of 13.2 than the use of purely local barometric changes. As regards time effects, it appears that both at Newlyn and at Liverpool variations in atmospheric pressure are anticipated by about four hours by corresponding sea level changes. Doodson quotes a similar condition in Newfoundland where anticipation of coming storms is shown by a change in the magnitude and direction of the currents some twelve hours prior to the onset of the storm.

Mr. Ogura begins his paper with a brief historical review of the problem of the relation of atmospheric pressure to sea level and follows with a discussion of the method of determining daily sea level from tidal observations. The main body of the paper deals with the effect of atmospheric pressure on sea level at a number of small islands in the western part of the North Pacific Ocean. He employs the same method as Prof. Wegener, comparing the curves of sea level and atmospheric pressure. This comparison shows that changes in sea level followed changes in atmospheric pressure from zero to four hours, while the height relations at the different places varied from 12 to 38; but the higher values are somewhat uncertain. Judging from Dr. Doodson's results it is probable that these higher values would be reduced considerably by employing the method of pressure gradients. The effect of the wind on sea level at these island stations Ogura found to be negligible.

H. A. MARMER

THE EVOLUTION OF LABOR UNDER PRIMITIVE MAN

L. H. DUDLEY BUXTON. **Primitive Labour.** viii and 272 pp.; index. Methuen & Co., Ltd., London, 1924. 7 s. 6 d. 7½ x 5 inches.

Anyone who would read this book from cover to cover will need to summon all his courage and perseverance. It was written in haste, apparently, and published in equal haste, before undergoing the revision which a work on this subject merited. The train of thought it often obscure, the paragraphing confused, and the language not merely labored but marred by exasperating errors.

The book is divided into three parts. The first attempts to trace the evolution of labor and its specialization. Part II treats of the influence of environmental factors such as climate and geographical location, concluding with a chapter on the environment of paleolithic man. Part III aims to amplify the two earlier sections by describing in greater detail the labor of selected peoples in different climatic zones; but

unfortunately the author frequently confuses labor with the products of labor, and this section of his book tends to become a wearisome, not too critical account of the material culture of certain tribes that seem chosen largely at random.

With all these defects the book has some outstanding qualities. Though it contains little that is truly original, it presents old facts and old theories in a new and instructive setting. When discussing the distinction between woman's work and man's work, the author rightly emphasizes that the heavier and more perilous tasks naturally fall to the man because of his physical superiority and that these tasks usually involve the providing of the principal necessities of life, such as food, clothing, and shelter; man supplies the raw materials for the daily life, and woman adapts them for the common use. The author accepts the theory—not an improbable one—that agriculture arose through women gradually learning to scatter in the vicinity of their homes the wild seeds and tubers they had collected in the woods and clearings; and he gives good reasons for rejecting Elliot Smith's hypothesis that agriculture began in Egypt with the cultivation of barley, whence it spread by culture contact to other parts of the globe, even to America. He retains the old classification into hunters, pastoral nomads, and agriculturists but clearly recognizes that these terms are not mutually exclusive and imply no priority in evolution of nomadism over agriculture. The chapters on the influence of climate and locality are perhaps the best in the book, but even here one feels that the author has not done himself justice. His wide travels and extensive reading have given him an unusually broad insight into the problems of man's evolution and development. More thought and care in the arrangement and presentation of his material would have produced a more readable book and one of more lasting merit.

D. JENNESS

THE NATURE OF GEOGRAPHY

CARL O. SAUER. **The Morphology of Landscape.** *Univ. of California Publs. in Geogr.*, Vol. 2, No. 2, pp. 19–53. Univ. of California Press, Berkeley, 1925. 45 cents.

In trying to find out just what the morphology of landscape is when stripped to the skin, the reviewer was reminded of an experience of student days while trying to run down and corner the organizing idea of geography. Learning that the great philosopher Immanuel Kant had published a Physical Geography, the reviewer found a copy of the edition of 1802 in the University Library and attacked it with "main strength and awkwardness." The professor of German having been called to the rescue, we succeeded in extracting from twenty pages the apparent meaning that, while history deals with the succession of events in time, geography deals with occurrences coexistent in space. During the same quest we were cheered by the discovery of the same idea expressed by the Scotch philosopher, Alexander Bain, that the foundation of geography is the conception of occupied space. The difference was like that between finding an amorphous boulder and a cut diamond.

There seems to run in the German blood the instinct and the ability to grasp an idea by placing it in the midst of all knowledge, like a single tree in a dense forest of all species. It seems to be equally native to the Scotch, French, and some English blood to get at a thing by isolating it, like a lone palm in the desert.

Professor Sauer's brochure begins with allusion to the fairly coherent series of viewpoints concerning the nature of geography, presented through the presidential addresses before the Association of American Geographers, which are accepted as a mirror and mold of geographic opinion in America, and proceeds to reëxamine the field, keeping especially in mind current views abroad. Of 56 references, 34 are to works in German, 7 in French, and 8 in English.

The experience of mankind, not the inquiry of the specialist, has made the primary subdivisions of knowledge. Area, or landscape, is the field of geography, because it is

a naïvely-given, important section of reality. Geography assumes the responsibility for the study of areas because there exists a common curiosity about that subject. It existed long before the name was coined. His field being thus well established in primitive human instinct, as well as in the philosophical "space" of Kant and Bain, the geographer may proceed calmly to cultivate it. Parenthetically it may however be remarked that the thought of what super-Euclidian geometry and Einstein's relativity may do to the geographer's "space" and the historian's "time" is liable to give both a bad half hour.

Then, according to Hettner, "a general earth science is impossible of realization; geography can be an independent science only as chorology." To discover the areal connection of phenomena and their order is the only task to which geography should devote its energies. The term "landscape" is proposed to denote the unit concept of geographic association of facts; to take the place of χώρα, land, pays, region, area, landschaft; and is defined as a distinct association of forms, both physical and cultural, having an organic unity different from both physical process and environmental influence, although it may include both. Geography being anthropocentric, the prime physical qualities of landscape are those that have habitat value, present or potential. The first, or physical, half of the content of landscape consists of the sum of all natural resources that man has at his disposal in that area. It is beyond his power to add to them; he may ignore, develop, exploit, or destroy them. The second half of landscape is its cultural expression, or the impress, of the work of man upon the area.

Morphology rests upon the postulates that there are units of organic or quasi-organic structure made up of definite component forms, that similarity of form is determined by functional equivalence, the forms thus being homologous (in biology organs having similar functions are not homologous but analogous), and that the structure units may be placed in developmental sequence, varying from incipient to final or complete stage. In geography the morphological method has been perverted to the genetic science of land forms, a valuable field of knowledge, but unrecognizable as geography. Climatology has been crowded into a relatively obscure position but has escaped the geographically sterile pursuit of pure genetic method.

The first step in geographic morphology is sytematic description, a process seriously hampered by the meagerness of vocabulary. The studies in geography of the school of Davis represent the most determined attempt to oppose uncontrolled freedom of choice in observation. The general description scheme of Passarge, intended to catalogue areal facts, is the most adequate consideration, by far, that the whole matter of geographic description has had. His capacious dragnet is a device fashioned by experienced hands for catching all that may be wanted in an areal morphology and for deferring explanation until the material is sorted.

Such a claim as this seems to force the question whether Passarge, or any other man of experience, can observe and describe phenomena without the use, conscious or unconscious, of working explanatory hypotheses. If he does, the result is likely to be a catalogue half rubbish, like a child's collection from a dump heap, and wholly unscientific.

The area prior to the introduction of man's activity is represented by a body of morphological facts, which may be called the original natural landscape, and belongs to the field of geology. In many parts of the world it no longer exists but must be reconstructed as a datum line, from which changes in cultural landscape may be measured. The geographer is not concerned with historical geology but with geognosy and still more with climate, which in time may develop a distinctive landscape, canceling the geognostic factors. The relation of climate to landscape is expressed in part through vegetation, which arrests or transforms the climatic forces. The author expresses the relation of natural landscape to forms, time and causal factors by a diagram, and in a similar diagram shows the relations in the morphology of the cultural landscape, or geographic area in its final meaning.

Under the influence of a given culture, itself changing through time, the landscape undergoes development, passing through phases, and probably reaching ultimately the end of its cycle. With the introduction of a different cycle, a rejuvenation of the cultural landscape sets in or a new landscape is superimposed on remnants of an older one. The shaping force, however, lies in the culture itself. This is the meaning of adaptation, through which we get the feeling of harmony between the human habitation and the landscape into which it so fittingly blends.

The paper closes with a caustic attack, based upon Vidal de la Blache and other French writers, upon the doctrine of environmental "control," or "influence," or "adjustment," which has been advertised abroad as the American definition of geography. Yet the author quotes with approval, as applicable to the geographer, the statement of Wissler concerning the anthropologist, that "he is not only trying to show what all the forms and forces of nature have done to man, but even with more emphasis what man has done to nature." This is letting something more than the nose of the environmental camel into the morphological tent. It would be difficult to devise a statement in which American geographers could, with varying degrees of emphasis on either wing of the antithesis, more nearly agree.

A serious discussion of the field, objects, and methods of scientific geography by a young, competent, and ambitious geographer is always timely and profitable. A careful study of Professor Sauer's brochure leaves the reviewer in doubt whether Landscape Morphology, corrected for personal equation, would work out in practice a result essentially new. It would be a most edifying experiment in coöperative research if Messrs. Davis, Fenneman, Barrows, Russell Smith, Wellington Jones, and Sauer could arrange to make each an independent study of the same chosen area and let the geographers of the world compare the results.

The stock from which "The Morphology of Landscape" is a rather exotic development has its roots far back in human and prehuman instincts and has been cherished and cultivated longer and more persistently than any other in the domain of phenomenology. It is still sound and vigorous and producing gorgeous flowers and delectable fruit. Although the sample offered by Professor Sauer is open to the suspicion that it may have been subject to the wizardry of his neighbor, Burbank, it is reassuring to know that interesting mutants are likely to appear indefinitely.

"Nothing in nature could be what it is except as an ingredient in nature as it is."

CHARLES REDAWAY DRYER

CORRESPONDENCE

In the January number of the *Geographical Review* (pp. 122–132) there appeared a review of Walther Penck's "Die morphologische Analyse," an advanced copy of which was sent to Professor Albrecht Penck. Under date of December 30, 1925, he replies as follows:

Your review of "Morphologische Analyse" is one of the most detailed which has been written of the posthumous work of my son, and for this reason alone it is particularly valuable to me. But above all I welcome this review because of its critical content; because, according to my opinion, the greatest esteem for a work is expressed not by simply abstracting its contents but by testing them and assuming a definite attitude towards them. The manner in which you do this is of the greatest interest to me. You proceed from the standpoint of the physiographer who primarily expects explanation of the land forms, and I must agree fully with you that today mere description of the forms is not sufficient, but that we must conceive every form to be primarily a link in a definite developmental series. That is the permanent contribution of Davis that he has brought this point of view into modern physiography.

But a land form can also be taken as the point of departure of other observations. Every form, F, is the difference between crustal movements, K, which have already

taken place and which are still taking place on the one hand and degradational or aggradational processes, A. The formula then holds

$$F = K - A$$

An explanatory description of the forms will always be expressed in terms of K and A. But if we consider this equation we see that, in the expression K − A, we know very little of K, the crustal movements, whereas we understand fairly well the degradational or aggradational process, A, and the form itself, F. If we wish to determine the unknown from the known we must put the equation in the form

$$K = F + A$$

There thus results a clear expression for that which my son wishes to do in his "Morphologische Analyse"; namely, he wants to make deductions from the different types of land forms on the earth as to the intensity of crustal movements. That is propounding a new problem which does not coincide with Davis' geographical cycle and therefore requires a quite different treatment. Of preliminary studies of this nature Walther found very few. Examples were not available from all over the world; he had to choose them from the regions which he himself had studied from this standpoint. For this reason the German Mittelgebirge and the Puna de Atacama play so large a rôle in his book, and only where he deduces analogous conditions in North America does he go into these in more detail. But in this he does not base himself on the abundant application of the cycle theory in America but on a divergent point of view and an individual conception of the objectives of the problem. For this reason, of course, many publications are missing in his bibliography which are closely related to the cycle theory without having any direct connection with the question of morphological analysis. How great the divergence is in these matters is best shown by calling attention to the ascending and descending development between which my son differentiates and which has never been mentioned in the cycle theory so far as I know (I must always make this proviso, as I am only partially familiar with the literature of the years 1914–20 because of the war and the subsequent scientific blockade of Germany): ascending development with convex, descending with concave forms. The former are widely prevalent in the German Mittelgebirge; but the latter are not lacking, although so far little attention has been paid to them. In Africa they give the characteristic impress to wide areas. Davis' monadnocks belong to this category, and my son's exposition brings them into organic contact with the surrounding erosional surfaces.

The fundamental differentiation between ascending and descending development is based on the differentiation of two dissimilar processes which in England have always been kept separate but which in North America have often been combined, namely the processes of erosion and of denudation, the former linear, the latter areal in its action. Davis here recognizes no fundamental difference; my son clearly demonstrates this difference. You, too, in your review attach no importance to this point and speak of old erosional surfaces when my son means denudational surfaces or degradational surfaces in general. The third point in which you do not entirely understand my son is the circumstance that you always consider his investigations only as a contribution to the cycle theory and believe that, if he had avoided the suggestive power of the expressions young, mature, and old, his conclusions would nevertheless be in complete accord with those of American investigators. My son set up an entirely different problem from Davis. It was not in the least his aim to reform Davis' cycle or even to establish a new system on the basis of special cases. Davis wants to explain the manifold forms of a landscape, and Walther Penck wants to deduce from them the intensity of crustal movements. That in so doing he makes some mention of the cycle goes without saying. He conceives it in a broader, a more general manner than Davis. While Davis lays the main emphasis on the factor time, Walther places in the foreground the intensity relation of the processes, viz. the effect of processes in a given time unit. Davis thereby is naturally led to the terms young, mature, old; Walther to the recognition of the fundamental difference between ascending and descending development. It is Davis' great merit to have introduced the factor time into morphological thinking. That had to be done before the intensity relation of the acting causes could be studied.

Professor Penck's letter deserves appreciation first because of its clarity and second because of its tone. It would be a benefit to physiography if the questions it raises and the considerations advanced in the reviewer's criticism of Walther Penck's book were further discussed by others in the spirit of his reply. We are not discussing questions which can be resolved at once. Some of them will hardly yield to physiographic analysis at all. In the meantime the challenging nature of the questions

can hardly fail to stimulate that specialized field research which will yield further critical information.

A few additional criticisms of Walther Penck's thesis are suggested by Professor Penck's letter. In the expression K = F + A and in the clause "my son wants to make deductions . . . as to the intensity of crustal movements" as well as in the whole meaning of Professor Penck's letter we have apparently a statement at variance with his previous letter. On page 126 of the reviewer's article is a quotation from his earlier letter which ends as follows: "the cycle theory, as my son develops it. . . ." According to his present letter it was not a cycle theory that was his son's main object. See further in the present letter: "My son set up an entirely different problem. . . ." "It was not his intention to reform Davis' cycle. . . ." In short, says he, Davis explains the forms; Walther Penck deduces from them the intensity of crustal movements. In doing so Walther Penck uses the ideas of ascending and descending development of forms. That is, in a general analysis of land forms he has a new mode of approach based upon a different view as to which is the most important organizing principle in physiography: i. e. (a) the theory of the topographic cycle or (b) the conception of topographic changes in ascending or descending sequence. With this there can surely be no quarrel. Fortunately human judgments of values are as variable as the peoples poured into the varying regional molds that make up the earth. And this is as true of physiography as it is of art.

But the approach suggested by Walther Penck has limitations of value and scope not inherent in Davis' cycle theory. In closing the discussion only brief reference may be made to such limitations. Previous reference was made (p. 132) to the "fine edge of correlation" between topographic forms and crustal movements of an isostatic nature. If climatic conditions were uniform and topographic profiles and related data available in full measure for all elevations the problem could be expressed if not solved almost in mathematical terms. But the opposite conditions really prevail. To dissociate isostatic and climatic elements is almost a task of despair in numberless cases. That is, we can only state the value of K in rough terms and then only in some cases under special conditions. An elaborate argument may be built up, but it is a superstructure whose stability may be threatened by a single weak foundation stone. By contrast Davis sets up really approachable limits. He attempts to express the stage that a topographic form has reached in terms of the whole sequence of stages from its initial to its ultimate form. That his expression of the form may be refined *at any stage or at all stages* by the closer analysis of causes or by a more minute subdivision of classes of form in regions where varying relations of form to rates of uplift occur he would be the first to admit. For it is a growing principle that he established; just as evolution is a growing principle, and not a dead system rigid in concept and precisely final in form.